

Theses on information imperfection, market failure and remedy

Yi Fang

A thesis submitted in fulfilment of the requirements for the degree of Doctor of

Philosophy

University of Edinburgh

2007



To My parents
and
My fiancée Jing Cai

Declaration

I certify that this thesis does not incorporate without acknowledgement any material previously submitted for a degree or diploma in any universities; and that to the best of my knowledge it does not contain any material previously published by another person where due reference is not made in the text.

Yi Fang, April 2007

Acknowledgements

I am deeply indebted to my supervisor, Professor Jozsef Sakovics and Professor Andy Snell, for their very helpful comments and encouragement.

I wish to thank Professor Ed Hopkins for the encouragement during my Phd study.

I also wish to thank Professor John Moore and Professor Jonathan Thomas for their insightful comments at the Phd workshop.

I am also very grateful for the support of Professor Seth Armitage for providing me an excellent database.

Special thanks to Professor Andy Snell, Mr. Stuart Sayer, SGPE and the School of Economics for providing me teaching opportunities and Scholarship.

And also thanks to Ms Kay Cruickshank and Mrs Lorna Aitken for their administrative supports.

Last but by no means least, to Xinhuan Li, Jane Qiu and my dear friends in China for their wit and wisdom.

Abstract

The two research chapters of this thesis are weakly related in the sense that one of them focuses on the market failure induced by information imperfection and the other focuses on the market failure exacerbated by information imperfection. We study the first type of market failure in the context of corporate equity finance and study the second in the context of long-term bilateral transactions.

In the equity finance market, adverse selection may arise due to the asymmetric information of firms' value. It has been argued that firms, in response to the inefficiency induced by adverse selection, may signal their unobservable values through choices of equity flotation methods. In the context of UK open offers and rights offers, we provide evidences for this signalling hypothesis. We find that information content of trades marginally significantly falls after both rights offers and open offers. This result suggests adverse selection gets less severe post equity offers. And it in turn implies that asymmetric information is resolved with equity offers. Together with Armitage and Snell (2003)'s finding of positive price effects of UK open offer and negative price effects of rights offers, our result suggests that asymmetric information is resolved with firms' choices of equity flotation methods, and that open offers are employed by good firms to signal quality to the market.

In addition to the signalling hypothesis, we establish some patterns of adverse selection in London SEAQ. Information content of trades is related to trade size. Small trades are not informative, while median trades and large trades are informative. For the comparison between purchases and sales, large purchases are more informative than large sales, while median purchases are less informative than median sales. These results suggest that informed traders handle large purchases and large sales with different strategies. They also imply that market makers are less harsh to traders with positive private information. With some preliminary evidence, we set up a hypothesis of the pattern of human intermediation in London SEAQ: human intermediation works in a "carrot" format when private information is more costly to obtain and adverse selection is more severe; it works in a "stick" format when information of a stock can be generated less costly and market makers face fewer threats from informed trading.

In most of long-term bilateral trading relationships, transaction parties have to make investments which are geared towards their partners. Once the investments are sunk, a party can not rely on market to discipline his partner, and his investments return will be vulnerable to expropriation. This problem, known as the hold-up problem, will discourage parties from making socially desirable investments. Due to information imperfection, the hold-up problem can not be solved by complete contracting.

The theses reconsider the hold-up problem by allowing a party to separately invest in his outside option in order to capture its value. We find that after considering this investment option, the hold-up problem is potentially more severe than previously observed. Unproductive investments may be made just to accumulate bargaining power. These inefficient investments may crowd out relationship specific investments; even worse, the socially efficient relationship may break because of them. All these inefficient outcomes can happen where in the previous formalization of hold-up, socially efficient outcome is the unique equilibrium outcome.

Based on our set-up, we find that exclusive contracts can affect investment incentive. The presence of exclusivity sufficiently reduces the sensitivity of a party's payoff to his investment in his outside option. As long as his investment in the outside option is less productive than his relationship specific investment, his incentive to invest outside will be wiped out. We also find that exclusivity improves efficiency when relationship specific investments are sufficiently productive, but worsens it when they are sufficiently unproductive.

Content

Introduction of the thesis.....1

Chapter 1

Review of Literature on SEOs Price Effects

1.1 Introduction5

1.2 Some basic features of UK SEOs flotation methods.....7

1.3 Adverse selection and signalling approach.....11

1.3.1 Equity finance in a world of asymmetric information12

1.3.2 Signalling with equity selling price.....13

 1.3.2.1 Signalling with private placement discounts.....14

 1.3.2.2 Signalling with rights-offer subscription price.....15

1.3.3 Information production by the capital market.....17

1.3.4 Choice of SEOs flotation methods based on adverse selection and signalling approach.....20

1.4 Agency cost and control approach.....28

1.4.1 Some organizational features of public-traded firms.....28

1.4.2 Capital market discipline.....31

 1.4.2.1 Monitoring by large outside shareholders.....32

 1.4.2.2 Some criticisms on the role of large outside shareholders.....36

1.5 Conclusion.....38

Chapter 2

Adverse Selection in London SEAQ, A Review

2.1. Introduction.....39

2.2 Adverse Selection and Bid-Ask Spread.....40

2.3 Systematic Patterns of Adverse selection.....41

2.3.1 Trade size and adverse selection.....42

2.3.2 Trade time and adverse selection.....	44
2.3.3 Human intermediation and adverse selection.....	45
2.4 Conclusion.....	51

Chapter 3

Detect information content of trades in LSE with application to examine the Signalling Hypothesis in the SEOs Literature

3.1 Introduction.....	52
3.2 Data and Descriptive Statistics.....	56
3.2.1 Sample description.....	56
3.2.2 Descriptive Statistics for Firm Characteristics.....	57
3.2.3 Descriptive Statistics for Spread and Trading Characteristics.....	59
3.2.3.1 Data Filter.....	60
3.2.3.2 Descriptive Statistics for Spreads.....	61
3.2.3.3 Descriptive Statistics for Trading Characteristics.....	64
3.2.3 Summary for Section 3.2.....	66
3.3 Spread regressions.....	67
3.3.1 Methodology.....	68
3.3.2 Results for Specification (a) and (b).....	70
3.3.3 Results for specification (c) and (d).....	71
3.3.4 Summary for Section 3.3.....	73
3.4 Decomposing Bid-Ask Spread.....	73
3.4.1 Overview of the Spread Theory.....	74
3.4.2 Decompose spread models.....	76
3.4.2.1 Huang and Stoll (1997).....	76
3.4.2.2 Madhavan, Richardson, and Roomans, (1997).....	77
3.4.2.3 Glosten and Harris (1988).....	79
3.4.3 Empirical Results.....	80
3.4.3.1 Estimation Procedure.....	80
3.4.3.2 Estimation result.....	81

3.4.4 Critique of Decomposing Spread Model.....	84
3.5 Price Impact Analysis.....	85
3.5.1 Methodology.....	86
3.5.2 Data.....	90
3.5.3 Empirical results.....	93
3.5.3.1 Information content and trade size.....	94
3.5.3.2 Asymmetric between purchases and sales.....	96
3.5.3.3 Resolution of asymmetric information.....	97
3.5.3.4 Comparison of information content of trades between open-offer and rights-offer stocks.....	104
3.5.3.5 Human intermediation in London SEAQ, “Stick” or “Carrot”.....	106
3.5.4 Summary for Section 3.5.....	109
3.6 Conclusions.....	111

Chapter 4

Hold Up with Endogenous Outside-Option

4.1 Introduction.....	113
4.1.1 A brief review of the Literature.....	116
4.1.1.1 Hold-up problem	116
4.1.1.2 Exclusive contracts and investment incentive.....	117
4.1.1.3 Summary of the review.....	123
4.2 The Model	124
4.2.1 Exclusive contracts.....	138
4.3 Conclusion.....	143

Table	144
--------------------	------------

Table 3.1 Descriptive Statistics for Firm Characteristics

Table 3.2 Summary statistics for Spread

Table 3.3 Summary statistics for trading characteristics.

Table 3.4 Summary statistics for changes in trading characteristics

Table 3.5 Regression results for specification (a) and (b)

Table 3.6 Panel A. Regression results for specification (c)

Table 3.6 Panel B. Regression results for specification (d)

Table 3.7 Statistics for MRR estimations.

Table 3.8 Statistics for refined MRR estimations.

*Table 3.9 Panel A. Summary statistics for market makers' quotes in OPEN OFFER
stocks*

*Table 3.9 Panel B. Summary statistics for market makers' quotes in RIGHTS OFFER
stocks*

Table 3.10 Summary statistics for trades in different size categories.

*Table 3.11 Panel A. Cumulative abnormal returns for OPEN- OFFER STOCKS PRE-
OFFER trades.*

*Table 3.11 Panel B. Cumulative abnormal returns for OPEN- OFFER STOCKS Post
OFFER trades.*

*Table 3.11 Panel C. Cumulative abnormal returns for RIGHTS- OFFER STOCKS Pre
OFFER trades.*

*Table 3.11 Panel D. Cumulative abnormal returns for RIGHTS- OFFER STOCKS
Post OFFER trades.*

Table 3.14 Panel I, Pattern of Human Intermediation, Open-offer stocks

Graph164

Graph 4.1, Equilibrium (O_S, I_B) , (IO_S, I_B) , and (I_S, I_B) , given $r < 1$ and $k > 0$

Graph 4.2, Equilibrium (O_S, N_B) , given $r < 1$ and $k > 0$.

Bibliography.....166

Appendix.....172

Appendix A. Robustness tests for results in Chapter 3.

Appendix B. Proof of Propositions and Corollaries in Chapter 4.

Introduction of the thesis

The First Fundamental Welfare Theorem states that when markets are complete, any competitive equilibrium is necessarily *Pareto Optimal*. It formalizes Adam Smith's claim that the "invisible hand" of the market can be relied upon to achieve optimal results.

However, there are a number of ways in which the situations in actual markets may violate at least one of the assumptions of this theorem. In these cases, market equilibria fail to be *Pareto Optimal*, a situation known as market failure.

The two research chapters of this thesis are weakly related in the sense that one of them focuses on the market failure induced by information imperfection and the other focuses on the market failure exacerbated by information imperfection. We study the first type of market failure in the context of corporate equity finance and study the second in the context of long-term bilateral transactions.

In the equity finance market, it is likely that a firm has a better knowledge about its value than outside investors do. This violates an implicit assumption of the fundamental welfare theorem that the characteristics of all commodities are observable to all market participants. Thus, we expect that the market equilibria fail to be optimal in the presence of the asymmetric information. And the inefficiency will be exacerbated by firms' adverse selection where a firm's equity finance decisions depend on its privately held information in a manner that adversely affects uninformed outside investors.

In response to the inefficiency induced by asymmetric information, equity finance market may adapt by allowing for the possibility of signalling. It has been argued that firms may signal their unobservable values through choices of equity flotation methods (e.g. Eckbo and Masulis (1992)). Armitage (2002) and Armitage and Snell (2003), in the context of UK open offers and rights offers, claim that open offers allow potential placees to investigate the issuers, and that it is the placees' willingness to buy at the offer price that informs the market about the issuers' value. Armitage and Snell (2003) establish that there exists equilibrium in which good firms signal their quality by choosing open offers.

Surprisingly, there have been so far no definite empirical evidences for the signalling hypothesis. *Chapter 3* of the thesis attempts to make up this gap. In the context of UK open offers and rights offers, we attempt to establish that good firms signal quality with open offers.

If good firms do signal quality with open offers, asymmetric information of firms' values must be resolved with equity offers. The reason is that the market can observe a

firm's choice of flotation methods and can infer the firm's quality from its choice. Thus insider information will be revealed to the market with equity offers.

To examine the resolution of asymmetric information, we can rely upon transactions in the secondary market. If asymmetric information of a firm's value is resolved, the amount of private information about the firm is reduced. As a result, in the secondary market, informed traders' informational advantage over market makers is lessened. Adverse selection in the transactions of the firm's stock will be less severe.

Therefore, the hypothesis of resolution of asymmetric information can be tested by identifying the changes of adverse selection in the secondary market transactions during equity offers. Negative changes suggest that asymmetric information is resolved with equity offers.

In *Chapter 3*, with price impact method, we find that information content of trades marginally significantly falls after both rights offers and open offers. This result suggests adverse selection gets less severe post equity offers. And it in turn implies that asymmetric information is resolved with equity offers. Together with Armitage and Snell (2003)'s finding of positive price effects of UK open offer and negative price effects of rights offers, our result suggests that asymmetric information is resolved with firms' choices of equity flotation methods, and that open offers are employed by good firms to signal quality to the market.

In most of long-term bilateral trading relationships, transaction parties have to make investments which are geared towards their partners. This type of investments, referred by the literature as relationship specific investments, is less valuable outside the relationship. Once the investments are sunk, a party can not rely on market to discipline his partner, and his investments return will be vulnerable to expropriation. This problem is known as the hold-up problem.

In the presence of the hold-up problem, without additional governing mechanisms, it is generally inefficient to place a transaction under market since opportunism can no longer be constrained absent of competition. Facing the risk of being held-up, a party will be reluctant to make socially desirable investments. A potential remedy is to place the transaction under a market contract. In particular, if information is perfect, complete contracting will be feasible and there will be no room for the hold-up problem. In real world, however, information is far away from perfect. It is very likely that crucial elements of the trading relationship can not be contracted upon. If so, the relationship will simply be governed by an incomplete contract. The literature on incomplete contracts has

established that as the environment gets sufficiently complex, an incomplete contract will be virtually worthless for the hold-up problem (Hart and Moore (1999)). If so, organizational modes other than market will be called upon to facilitate the transaction.

In this thesis, we do not attempt to offer a solution to the hold-up problem. Instead, we attempt to show that the previous works on hold-up understate the inefficiency induced by the hold-up problem since they do not consider the possibility of separately investing in a party's outside option.

In the hold-up problem set down by Grossman and Hart (1986), for example, transaction parties are not allowed to separately invest in their outside options, and the values of their outside options are merely a by-product of the parties' relationship specific investments. Since a party's outside option provides bargaining strength during ex-post negotiation, the party has extra incentives to make relationship specific investments and the existence of outside option partially offsets the under-investment problem induced by hold-up.

We claim that this type of formulation of hold-up is incomplete. Relationship specific investments per se may not be sufficient for a party to create and realize the value in his outside option. If so, the party should be able to separately work on its value. If these are true, outside option can actually be a source of non-cooperative and inefficient behaviours: a party may make unproductive investments in his outside option for bargaining power to avoid being held-up.

In *Chapter 4*, we re-formalize the hold-up problem by allowing a party to separately invest in his outside option in order to capture its value. The hold-up problem gets potentially more severe than previously observed. Unproductive investments may be made just to accumulate bargaining power. These inefficient investments may crowd out relationship specific investments. Even worse, the socially efficient relationship may break because of them. All these inefficient outcomes can happen where in the previous formalization of hold-up, socially efficient outcome is the unique equilibrium outcome.

Based on our set-up, we find that exclusive contracts can affect investment incentive. The presence of exclusivity sufficiently reduces the sensitivity of a party's payoff to his investment in his outside option. As long as his investment in the outside option is less productive than his relationship specific investment, his incentive to invest outside will be wiped out. We also find that exclusivity improves efficiency when relationship specific investments are sufficiently productive, but worsens it when they are sufficiently unproductive.

The thesis is organized as follows. *Chapter 1* and *Chapter 2* are literature reviews devoted to the *Chapter 3* empirical research. In *Chapter 1*, we review the theory on the SEOs price effects. The two most prominent approaches to the SEOs price effects are the adverse selection and signalling approach, and the agency cost and control approach. The first one studies the SEOs price effects in an environment of asymmetric information. It claims that the price effects come from the resolution of asymmetric information with firms' equity finance decisions and the associated flotation method choices. The second approach appeals to the agency problem in a public firm. It claims that the SEOs price effects come from the improved or worsened monitors on management after SEOs.

In *Chapter 2*, we provide a review of adverse selection in London SEAQ. In particular, we discuss how adverse selection affects market makers' valuation and hence market prices, and how adverse selection generates bid-ask spreads. Besides, we also explore how the pattern of adverse selection is related to trade size and trade time, and how the pattern is affected by human intermediation.

In *Chapter 3*, we test the signalling hypothesis in the context of UK open offers and rights offers. In addition, we establish some patterns of adverse selection in London SEAQ. Information content of trades is related to trade size. Small trades are not informative, while median trades and large trades are informative. For the comparison between purchases and sales, large purchases are more informative than large sales, while median purchases are less informative than median sales. These results suggest that informed traders handle large purchases and large sales with different strategies. They also imply that market makers are less harsh to traders with positive private information. With some preliminary evidence, we set up a hypothesis of the pattern of human intermediation in London SEAQ: human intermediation works in a "carrot" format when private information is more costly to obtain and adverse selection is more severe; it works in a "stick" format when information of a stock can be generated less costly and market makers face fewer threats from informed trading.

In *Chapter 4*, we re-examine the hold-up problem by allowing a party to separately invest in his outside option.

Chapter 1

Review of Literature on SEOs Price Effects

1.1 Introduction

There have been widely documented evidences that SEOs generate abnormal, mostly negative, stock price effects, e.g. Eckbo and Masulis (1992), Wruck (1989), Slovin, et al. (2000). The extents to which the market reacts to issue announcements are different depending on flotation methods, e.g. Eckbo and Masulis (1992).

Modigliani and Miller's (1958, 1963) famous irrelevant proposition states that the mix of equity and debt is unrelated to a firm's value in a frictionless and tax-free capital market. Their logic is simple. A firm's return stream is unaffected by its capital structure. Any opportunity to improve the firm's value by repackage its return stream through capital re-structure will lead to a pure arbitrage opportunity. The force of arbitrage will pull the firm's value toward "first-best" level. In equilibrium, capital structure is irrelevant.

But why SEOs have price effects and why the effects are different dependant on the flotation methods? To explain these phenomena, the literature considers the possibility that the market's perceptions of a firm's return stream can be altered by the firm's decision to sell equity. The literature also reconsiders the possibility that a firm's return stream can be altered by the firm's capital structure. Two lines of reasoning have been put forwards: adverse selection and signalling approach, and agency cost and control approach.

The first approach, started by Myers and Majluf (1984), argues that a firm is better informed about its own quality than outside investors are. In equity finance market, this asymmetric information gives rise to an adverse selection problem where overvalued firms are more willing to sell equity. The market rationally responds to the adverse selection problem by revising down its valuation of the issuers. Equity selling prices will be worsened. To mitigate the adverse effects of equity offers, a firm can signal its quality to the market. This can be done through choices of equity selling price, (e.g. Heikel and Schwartz (1986), and Giammarino and Lewis (1989)), and choices of equity flotation methods (e.g. Chemmanur and Fulghieri (1999), Armitage and Snell (2003), and Eckbo

and Norli (2004)). If signalling is differentially costly to firms of different qualities, a non-pooling equilibrium may exist. If so, firms' qualities will be revealed to the market and the market will update its valuation according to firms' signalling choices.

Agency cost and control approach reconsiders the notion that managers will maximize a firm's value. An essential feature of public companies is the separation of ownership and control. The preferences of managers and owners generally will not coincide. Incentive provision is necessary for managers to behave optimally from owners' point of view. Due to informational problem, complete contracting is impossible or prohibitively costly. Agency problem can not be solved inexpensively. One of the disciplinary powers over managers is from capital market. Market for corporate control can provide incentives for managers to behave well through take-over threats. How well the threats can discipline managers depends on a firm's capital structure. Shleifer and Vishny (1986) show that a tender offer is more likely to arise and succeed if the raider holds a substantial share of the firm at the time of offer. Since an SEO may alter a firm's shareholding structure, e.g. equity private placements tend to create outside block-holdings, the take-over threats the incumbent managers face may change with the offer, which will have effects on the managers' incentives to maximize the firm's value. Therefore, SEOs can affect a firm's future return stream and consequently its stock price.

Ever since Wruck (1989), researchers mostly find significantly positive announcement period abnormal stock returns associated with equity private placements, e.g. 4.4% in Wruck (1989) and 6% in Cronqvist and Nilsson (2005). Together with the widely documented evidences that significantly negative stock returns are associated with US firm commitment offers^{1 2}, it seems to support the agency cost and control approach. On the other hand, although the empirical findings can be interpreted in a way that is consistent with the adverse selection and signalling approach³, there have been so far no firm evidences that support the signalling hypothesis. Our empirical research in *Chapter 3* attempts to make up this gap. In the context of UK rights issues and open offers⁴, we attempt to establish that UK open offers are employed by high quality firms to signal quality to the market.

¹ E.g. Eckbo and Masulis (1992)

² US firm commitment offer tends to increase shareholder dispersion. Eckbo and Masulis (1995)

³ For example, Hertz and Smith (1993) use some noisy proxies for the degree of information asymmetric, e.g. firm values, to argue that private placements are employed to reduce information production cost.

⁴ UK open offers can be described as private placements with pre-emptive rights preserved.

In what follows, we provide a review of the two approaches to the SEOs price effects. Since SEOs price effects are different dependant on flotation methods, in Section 1.2 we briefly introduce some basic features of UK flotation methods. In section 1.3, we review the adverse selection and signalling approach. SEOs price effects are examined in an environment of asymmetric information. Firms, acting in the interest of existing shareholders, sell equity to finance investment projects. The market rationally expects an adverse selection problem and adjusts its valuation of the issuers downwards. To obtain better equity selling prices, good firms attempt to signal quality to the market. We will investigate a set of signalling instruments and discuss how the incentive to signal affects firms' choices of flotation method. In section 1.4, we review the agency cost and control approach. Agency problem is allowed and managers of a firm may not act in the interest of existing shareholders. Disciplinary power from capital market can curb the agency problem. We will investigate why and how this power may be varied with SEOs. Section 1.5 concludes.

1.4 Some basic features of UK SEOs flotation methods

The types of SEOs methods adopted in the UK are rights offers, open offers, private placements and bought deals. UK companies are very concerned with the certainty of the proceeds in an SEO. Compared with their US correspondences, the UK flotation methods allow more room for an issuer to gather information about potential investors' interests and to seek pre-commitment to buy or to underwrite shares before the issue is publicly announced (Armitage (2000)). An arranger is employed by the issuer to facilitate this pre-announcement book building process. The extent to which the arranger is involved is different dependent on the type of the issue. The arranger may act merely as a marketing agent in an uninsured rights offer, or as an underwriter in an open offer or a private placement, or may even purchase all the new shares as principal in a bought deal. Obviously, different types of offers give issuers different degrees of assurance of proceeds, and the risk borne by an arranger or underwriter varies accordingly.

Different types of offers target different groups of investors. Potential investors can be differentially informed, possess differential bargaining power, and have differential willingness and ability to supervisor management. Private placements and open offers help involve a small group of sophisticated investors; bought deals tend to increase the

holdings by numerous small and passive investors; rights offers help preserve an issuer's ownership structure.

- *Rights offers*

To protect existing shareholders' voting right, corporate law dictates that existing shareholders be granted the right of first refusal to purchase a new issue of voting stock. This entails that rights offers be the default method for a firm to raise new equity capital. In a rights offer, existing shareholders are given pre-emptive rights to purchase shares proportion to their current holdings during the offer period. Offer price is set at a discount of the pre-announcement market price so that the rights have a value. Existing shareholders can either take up their entitlement or sell the rights. Either way can ensure them the value of the rights.

Before a rights offer is publicly announced, the arranger of the issue may seek agreement to buy from the existing shareholders. The shareholders may pre-commit to buy or pre-renounce their entitlement. Through this process, the issuer can obtain a rough estimation about the take-up level. The take-up level is the fraction of new shares purchased by the existing shareholders. It reflects their willingness to participate and may be informative about the issuer's value (Eckbo and Masulis (1992)). In the UK, Rights offers have a mean take-up level of 84% (Slovin, et al. (2000)).

If the shares in a rights offer are entirely pre-committed, the certainty of proceeds is more or less guaranteed. Otherwise, the proceeds from the issue will be uncertain since there is always a possibility that the market price falls below the offer price before the new shares are fully subscribed. To guarantee the success of an issue, the issuer can set a low offer price to encourage pre-commitments and to reduce the possibility of the market price falling below the offer price. This does not harm non-subscribers since they can sell the rights. But in a world of asymmetric information, choices of subscription price may signal insider information. And a low offer price may convey a bad signal to the market, which adversely affects the market price and hence impairs the success of the offer (Heinkel and Schwartz (1986), and Slovin, et al. (2000)).⁵

Alternatively, the issuer can employ the arranger as an underwriter who commits to purchase any unsubscribed shares at the end of the offer period. This type of rights offers

⁵ Armitage (2002) provides a different explanation of the relation between negative market responses and deep rights-offer discounts. He finds that firms offering deep discounts are those that anticipate arrival of bad news during offer periods. And it is the potential bad news that causes negative market responses, not the deep discount itself.

is referred to as insured rights offers. The underwriter in an insured rights offer will be called upon to buy any unsold shares at the offer price up to the limit of its underwriting commitment. In the UK, it is common for the underwriter to diversify the underwriting risk by contracting with sub-underwriters (Armitage (2002)). They as a group provide a guarantee for the certainty of the proceeds. In the UK, rights offers are almost universally insured (Slovin, et al. (2000) and Marsh (1979, 1980)).

In the UK, rights offers tend to elicit negative market responses. Slovin, et al. (2000) find that over the post-deregulation period⁶, two day announcement average abnormal return for rights offers is -3.1%, statistically significant at the 1% level. For insured rights offers, the AAR is -2.9%, statistically significant at the 1% level; for uninsured rights offers, the AAR is even more negative: -5%, statistically significant at the 1% level.

- *Private placement*

An equity private placement is a non-rights method of flotation. Existing shareholders do not have pre-emptive rights to purchase new shares.⁷ Instead, shares are placed with one or more investors by private negotiation before the offer price is fixed and the issue is publicly announced (Armitage (2002)). During the negotiation, potential placees can investigate the issuer, decide whether and how much to buy, and indicate an acceptable price range. This information helps the issuer to set a mutually acceptable offer price, and helps guarantee the success of the issue.

A private placement is distinct in its selling process and its effect on ownership structure. In a private placement, the issuer sells blocks of new shares to a small group of professional investors and industry experts by negotiation. Insider information of the issuer can be transferred efficiently. A private placement is an effective mechanism for the issuer to alter its ownership structure. The identity and the size of the new share holdings can be controlled. And since a small number of investors purchase blocks of new shares, the offer tends to create block-holdings and increases ownership concentration.

By creating block-holdings, private placements effectively invite monitoring into the issuer's operation (Wruck (1989) and Shleifer and Vishny (1986)). Target investors in private placements are sophisticated in that with insider information and the high voting

⁶ Rights offers are the only SEOs flotation method in the UK before the mid-1980s; London stock exchange regulation changed in 1986 to broaden the choice of flotation methods available to firms in SEOs.

⁷ Shareholders must have voted in advance to dis-apply the pre-emptive rights.

and income rights, they are more likely to be active in management and corporate control contests.

Private placements tend to elicit positive market responses. With US private placement samples Wruck (1989) finds a significantly positive two day announcement AAR of 4.4%; Hertz and Smith (1993) find that of 3.28%. Cronqvist and Nilsson (2003), with Swedish private placement sample, document a significantly positive two day announcement AAR of 7.3%.

- *Open offer*

An open offer is a hybrid between a private placement and a rights offer. It can be described as a private placement with pre-emptive rights preserved. Before the announcement of an open offer, the arranger negotiates privately with investing institutions so that he has a list of placees by the time of announcement. However, the shares placed can be clawed back by existing shareholders who still have pre-emptive rights to purchase new shares. If existing shareholders do not wish to take up their entitlement, the shares are allocated among the placees at the offer price. An important difference between an open offer and a rights offer is that existing shareholders can not sell the rights in an open offer. Since take-up levels are low in UK open offers, on average about 50%, offer discounts do imply wealth losses. Most UK open offers are made at substantial discount (Armitage and Snell (2003)).

The placees in an open offer do not merely provide a guarantee for the proceeds. They will buy all the shares not clawed back by existing shareholders. The ownership effect of an open offer is similar to that of a private placement: new block-holdings are created after the offer.

In the UK, market responses positively to open offers. Armitage (2002) documents a significantly positive two day announcement AAR of 1.03%. Armitage and Snell (2003) find that of 1.5%, significant at 1% level.

- *Bought deals*

Bought deals are also non-rights flotation method. In a bought deal, an underwriter purchases the entire offer from the issuer on the spot at a fixed price. After that, the issue is announced, and the underwriter sells the shares to clients, with no further obligations

on the part of the issuer (Slovin, et. al (2000)). Compared with other types of offers, bought deals allow the issuers to obtain fund immediately without uncertainty.

An underwriter bears most risk in a bought deal since new shares are placed after the underwriter buys out the shares. Therefore the underwriter has most incentives to verify that the issuer is not overvalued. In the UK, market responds positively to bought deals. Slovin, et al. (2000) find that the two day announcement AAR for bought deals is 3.3%, statistically significant at the 1% level. They claim that this is because the reliability of underwriter certification is highest in bought deals. Overvalued firms will avoid the rigorous check by underwriters in bought deals, and choose other types of offers. On the other hand, undervalued firms have incentives to signal their quality and correct market price by passing the test and obtaining certification from underwriters. Therefore, firms conducting bought deals may probably be those undervalued. If so, the positive market reaction to bought deals is a result of signalling by undervalued firms.

In a bought deal, the issuer can not control the identity of its new shareholders. Ownership tends to be more disperse after the offer.

1.5 Adverse selection and signalling approach

In a world of asymmetric information, a firm's equity may not be fairly priced. Consider a firm whose equity is under-priced. When it issues new equity, there will be wealth-transfer from existing shareholders to new shareholders. Unless the new capital obtained can generate sufficiently large surplus, equity finance will not be considered.⁸ On the other hand, for a firm whose equity is over-priced, equity finance will be an ideal choice since existing shareholders can gain at the expense of new shareholders.

Under this logic, firms that issue new equity will probably be those overvalued. The market rationally expects this adverse selection problem and adjusts its valuation of the issuers downwards. The equilibrium may be that only bad firms obtain new equity capital. If new equity capital is necessary for an investment opportunity, good firms will have to give up the opportunity and under-invest.

To mitigate the underinvestment problem, a good firm can signal its quality to the market. For the signal to be credible, the signalling process must be costly, and differential costly for good firms and bad firms. The instruments with which to signal can be equity selling price (Heikel and Schwartz (1986) Giammarino and Lewis (1989)), and

⁸ Agency problem of a firm's managers is temporarily ignored in this section

certification by quality investigators (Heikel and Schwartz (1986), Chemmanur and Fulghieri (1999), Armitage and Snell (2003), and Eckbo and Norli (2004)).

If signalling results in a non-pooling equilibrium, a firm's quality will be (partially) revealed to the market, and asymmetric information will be (partially) resolved. The market will update its valuation of the firm with the new information. SEOs price effects arise. And the effects will be different depending on a firm's signalling choice.

1.5.1 Equity finance in a world of asymmetric information

Asymmetric information creates adverse selection in equity finance market. The market rationally reacts to this problem and adjusts down its valuation of issuers. The equilibrium outcome may be that under-priced firms under-invest and equity offers have negative stock price effects.

Myers and Majluf (1984) formalize the above idea. In their model, a firm, for some exogenous reasons, has to obtain new equity capital, E , to finance a new investment. The firm's value consists of two parts: the future return stream from existing assets, a , and that from the new project, b . The market can not observe a and b , but know the distribution of a and b .

The firm decides whether to issue new equity. The price of new equity is set by the market. Assume the market is competitive.⁹ The market's valuation of the firm conditional on issue can be expressed as,

$$V = E(a + b + E | \text{issue})$$

The firm will issue if and only if,

$$\frac{V - E}{V}(a + b + E) \geq a \quad (1.1)$$

Rewrite (1.1) as

$$\frac{V - E}{V}(b + E) \geq \frac{E}{V}a \quad (1.2)$$

Equation (1.2) has an intuitive interpretation: the firm will issue if and only if the gain from the new investment exceeds the loss to new shareholders. Restate (1.2) as,

$$b \geq \frac{E}{V - E}a - E \quad (1.3)$$

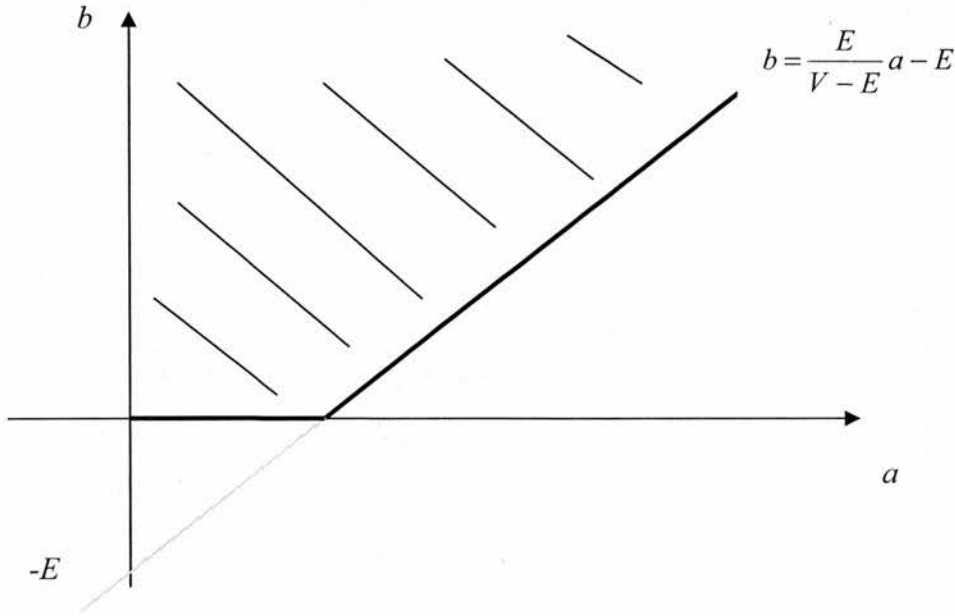
⁹ The market expects zero profit.

In equilibrium, the market's belief of the characteristics of an issuing firm is correct. The equilibrium condition is:

$$V^* = E(a + b + K) \left| b \geq \frac{E}{V^* - E} a - E \right. \quad (1.4)$$

Assume that the market does not collapse, that is, there exists V^* that satisfies (1.4). The graph below demonstrates the idea of the equilibrium.

Graph 1.1



The firm will issue if and only if its a and b fall into the shaded area. For any value of b , it is more likely to issue when its a is low. This generates the adverse selection problem.

Note that asymmetric information on b does not generate adverse selection. For any value of a , the firm is more likely to issue when its b is large.

Equity issue conveys a bad signal to the market. To see this, we compare the value of a firm's existing asset conditional on issue with that of another firm conditional on non-issue. It is clear that market reacts negatively to issuers.

$$E(a | b \geq \frac{E}{V-E} a - E) \leq E(a | b < \frac{E}{V-E} a - E)$$

1.5.2 Signalling with equity selling price

Myers and Majluf (1984) only allow firms to choose whether to issue or not. The resulting equilibrium is generally inefficient: good firms under-invest. However, in practice firms have more choices to make, e.g. equity selling prices and flotation methods.

Here comes the question: can a good firm use these choices to credibly convey inside information to the market, so that it can obtain equity capital less costly and mitigate the negative SEOs price effects?

The theoretical literature focuses on the choice of equity selling price and the choice of whether to invite quality investigators. Giammarino and Lewis (1989) show that in high growth industries, good firms can separate themselves with bad firms by offering deeper placement discounts. Heinkel and Schwartz (1986) show that in uninsured rights offers, good firms can signal their quality by setting higher subscription prices.¹⁰ These theoretical results are consistent with the empirical finding by Hertz and Smith (1993) and Wu (2004) on private placements, and Slovin, et al. (2000) on rights offers.

1.3.2.1 Signalling with private placement discounts

Hertz and Smith (1993) find that despite selling at substantial discount, private placements of equity elicit positive market responses. Armitage and Snell (2003) find a similar result in the context of UK open offers. The literature generally contends that the positive market reaction comes from the certification by placement investors and the deep discounts are the compensation to the investors for their information production costs, e.g. Armitage and Snell (2003).

Giammarino and Lewis (1989) offer another explanation. They claim that the deep placement discount can be a signal for good quality. Suppose that the value of a firm's existing asset, a , is relatively trivial compared with the value of its new investment opportunity, b . A good firm, with a larger b , is better able to give up ownership (or offer placement discount) to obtain finance. We demonstrate this with the following simple example.

Assume that two types of firms exist, good or bad. The values of their existing assets are a . A good (bad) firm's investment opportunity is worth b_G (b_B), with $b_G > b_B$. A firm's type is private knowledge. To obtain external finance E , the maximum fraction of ownership a good firm can offer a placee is $S_G^{\max} = b_G + E/V_G$, and the maximum a bad firm can offer is $S_B^{\max} = b_B + E/V_B$, where $V_i = a + b_i + E$, $i \in \{G, B\}$. It is easy to show,

¹⁰ Note that the welfare implication of signalling in these models is not clear. In the model of Giammarino and Lewis, the ability to signal with price does not help solve the under-investment problem. In that of Heinkel and Schwartz, the structure does not allow the discussion of under-investment.

$$S_G^{\max} > S_B^{\max}$$

A good firm is better able to give up ownership to obtain equity finance. This forms the basis for signalling. The proposition 3 in Giammarino and Lewis (1989) show that in the above case, there exists a semi-separating equilibrium where a good firm may signal its quality by offering the placee a deeper offer discount.

One may understand this with Myers-Majluf's model. Adverse selection arises from the asymmetric information of the asset values, while not from that of the investment value. In fact, the value of investment opportunities mitigates the adverse selection problem by enabling good firms to sell under-priced equity. One may imagine a case where the value of new investments is so large that adverse selection problem is suppressed.

Therefore, a deep placement discount may signal a good growth prospect of a firm. In reality, firms conducting private placements are usually small and are usually in high growth industries. The values of their investment opportunities are usually well above the values of their existing assets. For these firms, offer discounts can be an instrument to signal the quality of their investment opportunities. Since these firms' values are mainly from their growth prospect, the market will respond positively to offer discounts.

1.3.2.2 Signalling with rights-offer subscription price

In an uninsured rights offer, a firm's proceeds are not guaranteed since it is possible that the market price falls below the subscription price before the new shares are fully subscribed. To guarantee the proceeds, the firm can set a low subscription price. However, Slovin, et al. (2000) find that subscription price discounts have a significantly negative impact on the two day announcement AAR of their UK rights offers, which implies that subscription discount is a bad signal of firm value. Thus, setting a low subscription price may not help guarantee the proceeds since it adversely affects stock prices.

The result of Slovin, et al. (2000) also implies that subscription price may be a signalling instrument for good firms. A good firm is better able to set a high subscription price than a bad firm since the probability of arrival of bad news during the offer period is lower for a good firm. This forms the basis of signalling. Heinkel and Schwartz (1986) formalize the above intuition. They show that the equilibrium can be perfectly revealing: firms of different qualities set different subscription prices, with better firms setting higher prices. In what follows, we borrow the model of Heinkel and Schwartz (1986) to demonstrate how price signalling works in uninsured rights offers.

There are a set of firms. They have different qualities θ which is unobservable to the market. $\theta \in [\underline{\theta}, \bar{\theta}]$. For some exogenous reasons, they have to make uninsured rights offers at date 0.¹¹ Each issuer specifies a subscription price P which may be contingent on its quality.

At date 1, the offers expire, and issuers' value v , realize according to a distribution $f(\cdot; \theta)$. The values are observable to the market. The function $f(\cdot; \cdot)$ is common knowledge.

Since the issuers use uninsured rights offers, they have to assume the costs of issue failures. An issue will fail if at date 1, the issuer's value is below the subscription price. If an issue fail, the issuer will have to pay a penalty, C .¹²

An issuer's object is to maximize its stock price at date 0.¹³ Assume the market is competitive. The date 0 stock price is the market's expectation of the issuer's date 1 value, V , subtracted by the expected penalty cost.¹⁴

An issuer's strategy is a price function $P(\theta)$. The market's strategy is a belief function $V(P)$. In equilibrium, belief is consistent with strategy, which is optimal given belief. We will focus on separating equilibrium.

At date 0, an issuer with quality θ solves the following problem:

$$\underset{P}{\text{Max}} V(P) - \int_0^P C \times f(v; \theta) dv \quad (1.5)$$

The market's valuation of a θ issuer is,

$$V(\theta) = \int_0^{+\infty} v \times f(v; \theta) dv \quad (1.6)$$

In equilibrium, the market correctly infers the issuer's quality from subscription price,

$$V(P^*(\theta)) = V(\theta) \quad (1.7)$$

And function $P^*(\cdot)$ maximizes (1), which requires,

$$\frac{dV(P^*)}{dP^*} - C \times f(P^*; \theta) = 0 \quad (1.8)$$

Assume the maximum exists.

¹¹ The motivation of equity offers could be to finance a short-lived investment project.

¹² The penalty can be from foregoing a profitable project, or from using some other expensive sources to make up the shortage of fund.

¹³ The firm's manager may be on an incentive scheme in which his compensation is contingent on the stock performance at that date.

¹⁴ Heinkel and Schwarzdz assume away any dilution effects from equity offers.

If an equilibrium exists, (1.8) indicates that $\frac{dV(P^*)}{dP^*} > 0$, which means the higher the subscription price, the higher the market valuation. Differentiate (1.7),

$$\frac{dV}{dP^*} \frac{dP^*}{d\theta} = \frac{d}{d\theta} \int_0^{+\infty} C \times f(v; \theta) dv \quad (1.9)$$

Combined with (1.8), it yields,

$$\frac{dP^*}{d\theta} = \frac{\frac{d}{d\theta} \int_0^{+\infty} C \times f(v; \theta) dv}{C \times f(P^*; \theta)} \quad (1.10)$$

To better illustrate the idea of the equilibrium, assume a uniform distribution of $f(\cdot; \theta)$ over interval $[0, \theta]$. From (1.10), we have,

$$\frac{dP^*}{d\theta} = \frac{\theta}{2C} \quad (1.11)$$

Then the equilibrium price function can be put as,

$$P^*(\theta) = \frac{\theta^2}{4C} + L \quad (1.12)$$

Since signalling is not productive, the lowest quality θ issuer will not signal. That is, it will quote a price θ to avoid the loss from issue failure. Thus, $L = -\frac{\theta^2}{4C}$. The equilibrium price function can be pinned down as,

$$P^*(\theta) = \frac{\theta^2 - \theta^2}{4C} \quad (1.13)$$

From (1.13), we can see that the equilibrium is perfectly revealing. Issuers of different qualities will choose different subscription prices. The market perfectly infers the issuers' qualities with the subscription prices, and adjusts its valuation accordingly.

All the issuers in this separating equilibrium have to assume signalling costs. The signalling costs come from the expected losses from issue failure. Heinkel and Schwartz (1986) show that the signalling cost is an increasing function of θ . Higher quality issuers assume higher signalling costs.

1.5.3 Information production by the capital market

So far, we have assumed that the capital market is passive. It values a firm with its prior and the signal received from the firm. But in the actual market, participants can

engage in information production and become informed. These informed traders play a crucial role in the secondary market known as price discovery. They actively incorporate information into price and thus reduce the extent of asymmetric information.

Similarly, we expect that information production by the capital market will also affect the primary market. Asymmetric information may not be sufficient for negative SEOs price effects. Chemmanur and Fulghieri (1999) show that if investors can obtain a relatively accurate estimation of a firm with relatively low cost, a good firm's SEOs decision will not convey a bad signal to the market and the firm will not have to undersell its equity. Besides, the equity selling price will be more informative when the estimation is more accurate and when the cost of investigation is lower. When the estimation is more accurate, investors are better able to discern a good firm from a bad one, and thus a good firm can sell equity at a higher price. Investigation will take place when an issuer sets a high offer price. Investors' cost of investigation will be ultimately assumed by the issuer, and the way to compensate investors is by offer discounts. When the cost of investigation is lower, the cost for a good firm to set a high offer price will be lower since investors require less compensation. Therefore, the firm can set a higher offer price.

By passively relying on the capital market to produce information, the negative SEOs price effects can be mitigated. However, doing so may be quite costly. Since there is no coordination in the process of information production, it is likely that there are huge amounts of duplication of investigations. All these investigation costs will ultimately be assumed by the issuer. This will be especially costly if the issuer is a young firm and is in a high growth industry in which case the information is difficult to obtain and evaluated. In this case, it is better for the issuer to limit the investigators to a small group of professional investors.

When the cost of information production is high, instead of passively relying on the capital market to produce information, a firm can invite some sophisticated investors into the issue process. Hertz and Smith (1993) and Cronqvist and Nilsson (2005) find that when the degree of asymmetric information is high, it is more likely for a firm to conduct equity private placements.

These sophisticated investors not only save costs in information production, but also provide certification for the issuers. Slovin, et al. (2000), Armitage (2002) and Armitage and Snell (2003) argue that the underwriters in UK bought deals and placement investors in private placements and UK open offers will investigate issuers. Their willingness to buy shares certifies to the market that the issuers are not overvalued.

Bought-deal underwriters and placement investors commit not only a large amount of fund but also reputation in an issue. They have more incentive to investigate a firm than small investors, and are able to communicate the information credibly to the market. A firm can invite them to justify its equity price in an issue. In what follows, we use the model in Hertz and Smith (1993) to demonstrate the idea of certification by quality investigators.

A firm has a short-lived investment opportunity worth b , which requires an amount E external equity finance. The firm's asset value is a ($a \in \{a_B, a_G\}$, $a_B < a_G$) which is private information.

The firm has three choices: public offers, private placements or no offers. In a public offer, the firm sells new equity to numerous small investors, while in a private placement it sells to a placement investor. Assume that small investors are passive and competitive. To obtain a benchmark result, assume a polar case where the placement investor can costlessly investigate the firm and assess a perfectly. Also assume that the placement investor can charge a payment T from the firm and that this payment takes the form of offer discounts.^{15 16}

We focus on a full separating equilibrium where a good firm chooses private placements, and a bad one chooses public offers. If the equilibrium exists, the payoffs of the two types of firms in the equilibrium are,

$$\text{Good firms: } a_G + b - T$$

$$\text{Bad firms: } a_B + b$$

For a good firm not to deviate, the following conditions must be satisfied,

$$a_G + b - T > \frac{a_B + b}{a_B + b + E} (a_G + b + E) \quad (1.14)$$

$$a_G + b - T > a_G \quad (1.15)$$

For a bad firm not to deviate, the following conditions must be satisfied,

$$a_B + b > a_B + b - T \quad (1.16)$$

$$a_B + b > a_B \quad (1.17)$$

¹⁵ This assumption can be justified if the result of investigation is verifiable so that an ex-ante contract can exist between the placement investor and a firm choosing private placements.

¹⁶ The payment T can be the compensation to the placement investor for information production and for the risk of holding undiversified securities, and can be a result of the placement investor's bargaining power. Note that the first interpretation does not apply in the current set-up.

Bad firms' constraints do not bind. The conditions for the full separating equilibrium to exist are,

$$\frac{a_G + b - T}{a_G + b + E} > \frac{a_B + b}{a_B + b + E} \quad (1.18)$$

$$b > T \quad (1.19)$$

Apparently, when T is sufficiently small, (1.18) and (1.19) can be satisfied.

Condition (1.18) means that private placements are employed by a good firm if the proportion of ownership retained by existing shareholders under full information exceeds the proportion retained if it is mixed with bad firms.

In this equilibrium, despite the fact that the new equity is sold at a discount, $\frac{E}{E+T}$, a private placement elicits positive market reactions due to the certification by the placement investor.

The above result is based on an extreme assumption that investigation by the placement investor is costless and perfect. In the less extreme cases where investigation is costly and imperfect, it is still reasonable to expect that the equilibrium of the game reveals information if investigation is sufficiently perfect and not that costly, and if the payment to the placement investor is at a median level.¹⁷ If so, the market will react positively to private placements due to the effect of certification.

Consistent with the idea of certification by quality investigators, Slovin, et al. (2000) find that UK bought deals elicit positive market responses; Armitage (2002) and Armitage and Snell (2003) find that UK open offers and private placements elicit positive market responses. These results imply that certifications by bought-deal underwriters and placement investors are sufficiently reliable in the UK, and that good firms can signal quality to the market by choosing these flotation methods.

1.3.4 Choice of SEOs flotation methods based on adverse selection and signalling approach

Choice of SEOs flotation methods is about obtaining fund with minimal expense.¹⁸ In a world of symmetric information, this can be done easily, simply by choosing the flotation method with the lowest direct cost. However, in a world of asymmetric information, the

¹⁷ For example, imagine a semi-separating equilibrium where good firms choose private placements, while bad firms use a mixed strategy which assigns a positive probability to choose private placements.

¹⁸ Agency related problem will be discussed in the next section.

problem of guaranteeing the success of an issue and selling equity at a good price arises. This triggers signalling costs and information production costs. Sometimes, these implicit costs are so high that all firms prefer to avoid them: in US, rights offers almost demise despite the fact that they are less costly in term of direct costs than underwritten offers.¹⁹

In other cases, the fact that good firms are more able to bear these implicit costs forms the basis of signalling. Since different flotation methods trigger different levels of implicit costs, the signalling process may boils down to the choice of flotation methods. In Heinkel and Schwartz (1986), good firms signal their qualities by choosing rights offers and the associated subscription prices; bad firms avoid the signalling costs by choosing US underwritten offers. In Chemmanur and Fulghieri (1999), good firms signal by choosing private placements where they incur the costs of investigation; bad firms choose US underwritten offers where they incur no costs of information production but obtain a low selling price.

Armitage and Snell (2003) study firms' choices between private placements and rights offers. They claim that the placing process in private placements requires issuers to undergo inspection, while there is no inspection in rights offers. Since good firms are better able to pass the inspection, they may signal quality by choosing private placements. However, in the UK, the signalling cost is substantial: placees often require deep placement discounts from the issuers. Even good firms may not want to assume the signalling cost, since alternatively they can pool with low quality firms to choose rights offers in which new shares are sold at a higher price. Thus, maximising equity selling prices may not be the motive for good firms to choose private placements. Armitage and Snell (2003) argue that the motive for private placements is that firms attempt to signal quality and correct market prices with a view to subsequent sales of shares.

In this section, we discuss a model by Eckbo and Norli (2004) which addresses the choice between rights offers and private placements. They bring the take-up levels into the picture and argue that the incentive for an under-priced firm to signal quality is determined by the firm's take-up level. In previous discussion of rights offers, we contend that offer discounts do not matter since non-subscriber can sell the rights. But if a firm is under-priced, even though non-subscriber can sell the rights, there is still wealth loss to outside investors since equity is undersold anyhow.

¹⁹ Brealey and Myers (1981), Eckbo and Masulis (1992)

If take-up level is high, e.g. 100%, an under-priced firm will have no incentives to signal quality because outside investors can not purchase the under-priced equity. On the other hand, if take-up level is low, in order to reduce wealth losses, the firm will assume costs to signal quality so as to raise its equity selling price.

Eckbo and Norli (2004) consider a firm's choice problem among uninsured rights offers, insured rights offers and private placements. In their model, what concern a firm are the direct cost of an issue and the implicit wealth losses to outside investors in an issue. Wealth losses occur when in an issue, the firm's equity is under-priced. The firm can mitigate the wealth losses by choosing rights offers or by signalling quality. If its take-up level is high, choosing rights offers can effectively reduce the wealth losses since outside investors are unable to obtain the under-priced new shares. Alternatively, the firm can signal quality by choosing insured rights offers or private placements in which the firm will undergo inspection. The direct costs of uninsured rights offers and private placements are assumed to be lower than that of insured rights offers. Eckbo and Norli (2004) establish a pooling equilibrium in which good firms and bad firms will all choose uninsured rights offers when their take-up levels are high; when their take-ups are at median or low level, uninsured rights offers are the least favourable choice; at median level, all firms prefer insured rights offers to private placements; at low level, all firms prefer private placements to insured rights offers. We review the model in what follows.

The Model:

A firm has a short-lived investment opportunity worth b , which requires an amount E external equity finance. The firm's asset value is a ($a \in \{a_B, a_G\}$, $a_B < a_G$) which is private information. Market knows the probability distribution of asset value: $p(a_G) = \phi$, $p(a_B) = 1 - \phi$. Current shareholders take up a fraction t of the new shares. Take-up in private placement is scaled down to λt , $\lambda \in [0, 1]$. Eckbo-Norli assumes t is publicly known.

Three flotation methods are available: uninsured rights (ur), insured rights (ir) and private placement (pp). The direct cost of issue is c_i ($i \in \{ur, ir, pp\}$). Eckbo-Norli assumes $c_{ur} < c_{ir}$, $c_{pp} < c_{ir}$.

Denote the number of new shares issued as n , and the number of shares post offer as M . A firm issues if and only if:

$$(1 - \delta(1 - t))(a + b + E - c) \geq a + tE \quad (1.20)$$

Where $\delta = n/M$

The left hand side is the post-issue wealth of existing shareholders; the right hand side is their wealth if no issue is made. tE reflects the fact that they contribute a fraction t of the investment.

Whether (1.20) is satisfied depends on the issue price, denoted as P . $P \times n = E$. Without loss of generality, normalize $M = 1$. (1.20) can be rearranged as:

$$b - c - \frac{E(1 - t)[a + b + E - c - P]}{P} \geq 0 \quad (1.21)$$

We may interpret the left hand side as the existing shareholders' gain from issues. It is made up of the gain from the investment excluding the direct issue cost (the second term) and the wealth transfer to new shareholders (the third term).

P reflects the market's belief of the firm's value.²⁰ The market forms belief according to its prior belief of the firm's type, the result of investigation and the firm's choice in equilibrium. A firm choosing uninsured rights will not undergo investigation. Investigation will happen when a firm chooses insured rights and private placement. The investigation is informative but imperfect:

$$\Pr(e = a_B | a = a_B) = y; \Pr(e = a_G | a = a_G) = y, \text{ with } y > 0.5$$

The investigation will reveal the true type of a firm with probability y . With only prior belief, the offer price P the market will accept is:

$$P = (1 - \phi)(a_B + b + E - c) + \phi(a_G + b + E - c) \quad (1.22)$$

As in (1.21), a firm's choice of flotation method is only affected by the last two terms of left hand side. Sum up those two terms and denote the sum as C_i . C_i can be interpreted as the overall cost of flotation method i . It includes the direct cost, and the implicit cost of wealth transfer.

$$C_i = c_i + \frac{E(1 - t)(a + b + E - c_i - P_i)}{P_i} \quad i \in \{ur, ir, pp\} \quad (1.23)$$

From (1.23), one can see that when take-up is high enough, the implicit cost of wealth losses in rights offers disappears, no matter what the equity selling price is.

The flotation game takes a sequential form. At the first stage, a firm can choose among ur , ir and pp , as well as no-issue. ur and no-issue are always feasible choices. A

²⁰ We again assume the capital market is competitive

firm choosing *ir* or *pp* will undergo an investigation, and the issue can happen if the firm pass the test. The game ends after the firm issues or if the firm chooses no-issue. If the firm does not pass the test, the game proceeds into the second stage. The second stage is similar with the first stage except that the issue method which the firm fails to undertake in the first stage is no longer available. The game will proceed into the third stage if firm does not pass the test again in the second stage. At the third stage, the choices remaining are *ur* and no-issue.

A firm will fail in an investigation if it is judged as a bad firm. If a firm pass the test, it will negotiate with the underwriter in *ir* or the placement investor in *pp* about the issue price. Assume that a firm has all the bargaining power and can make take-it-or-leave-it offer in a negotiation.

Eckbo-Norli focus on a pure-strategy pooling equilibrium where bad firms mimic good firms' choice. For the equilibrium to exist, it is sufficed to check the participation constraint of good firms. Because of pooling, the choice of a firm does not reveal any information. The market's belief about a firm's type is formed with prior and the result of investigation.

From (1.21) and (1.23), we know that a firm will choose the flotation method with lowest C_i . If take-up t is high, it is reasonable for a firm to choose *ur* since the direct cost of *ur* is the lowest and the implicit cost of wealth transfer is decreasing in t . Eckbo-Norli confirm this intuition in their *proposition 1*.

Eckbo-Norli proposition 1: *It is part of a pooling sequential equilibrium for issuers with high current shareholder take-up t , such that $t \geq \max\{t_{ib}, t_{1pp}, t_{1ir}\}$, to follow the flotation method path $\{ur\}$.*

When take-up level is high, a good firm will have no incentives to signal its quality to the market. Although its equity is under-priced, a good firm can employ rights offers to minimize wealth losses to outside investors. And since the direct cost of insured rights offers is higher than that of uninsured rights offers, a good firm will choose an uninsured rights offer. Bad firms will try to pool with good firms so as to sell equity at a better price. Since there is no cost of mimicking good firms, bad firms will also choose uninsured rights offers. In what follows, we describe the construction of the $\{ur\}$ equilibrium.

There are five off-equilibrium strategies: $\{ir, pp, ur\}$, $\{pp, ir, ur\}$, $\{ir, ur\}$, $\{pp, ur\}$ and $\{no\}$. The last one represents no-issue. To verify the equilibrium in *Eckbo-Norli proposition 1*, we need to prove that a good firm will not deviate to any of the five off-equilibrium strategies.

To prove that, we need to obtain the market's belief of a firm's type contingent on the off-equilibrium behaviours. Assume that the two types of firms are equally likely to deviate from $\{ur\}$. The market's belief of a firm which passes the first test is:

$$\varphi^1 = \frac{\phi y}{\phi y + (1 - \phi)(1 - y)} > \phi \quad (1.24)$$

Its belief of a firm which passes the second test is:

$$\varphi^2 = \phi \quad (1.25)$$

Eckbo-Norli claim that a firm which fails in the two tests and chooses back to ur is believed as ϕ since the market assumes the firm is playing the equilibrium strategy.

$$\varphi^3 = \phi \quad (1.26)$$

With these beliefs, we can find out the market price of a firm that passes the first test, the second test or fail in both tests. For example, for a firm that passes the first test and conducts private placement will have a price as:

$$P_{pp}^1 = (1 - \varphi^1)(a_B + b + E - c_{pp}) + \varphi^1(a_G + b + E - c_{pp}) \quad (1.27)$$

With these market prices and with (1.23), we can find out the off-equilibrium and equilibrium cost for good firms: C_{pp}^1 , C_{ir}^1 , C_{pp}^2 , C_{ir}^2 , and C_{ur}^0 . C_{pp}^1 is the cost for a good firm when it chooses private placements at the first stage, passes the test and obtain finance.

$$C_{pp}^1 = c_{pp} + \frac{E(1 - t)(a_G + b + E - c_{pp} - P_{pp}^1)}{P_{pp}^1} \quad (1.28)$$

C_{ir}^2 is the cost for a good firm when it fails in the test at the first stage, chooses private placements at the second stage and pass the test. The rest can be interpreted similarly.

For the equilibrium in *proposition 1* to exist, the following five incentive compatible constraints for good firms must be satisfied:

$$C_{ur}^0 \leq yC_{ir}^1 + (1 - y)(yC_{pp}^2 + (1 - y)C_{ur}^0) \quad (1.29)$$

$$C_{ur}^0 \leq yC_{pp}^1 + (1 - y)(yC_{ir}^2 + (1 - y)C_{ur}^0) \quad (1.30)$$

$$C_{ur}^0 \leq yC_{pp}^1 + (1 - y)C_{ur}^0 \quad (1.31)$$

$$C_{ur}^0 \leq yC_{ir}^1 + (1 - y)C_{ur}^0 \quad (1.32)$$

$$C_{ur}^0 \leq b \quad (1.33)$$

Constraint (1.29) means a good firm should have no incentives to deviate to strategy $\{ir, pp, ur\}$; Constraint (1.30) means a good firm should have no incentives to deviate to $\{pp, ir, ur\}$. The rest can be interpreted similarly.

Constraint (1.29) and (1.30) are not binding. The rest can be simplified as: $C_{ur}^0 \leq C_{pp}^1$, $C_{ur}^0 \leq C_{ir}^1$ and $C_{ur}^0 \leq b$. With these three constraints, we can solve for the three critical values of take-up, $\{t_{1pp}, t_{1ir}, t_{1b}\}$, above which the associated constraint is satisfied.

Eckbo-Norli proposition 2: *It is part of a pooling sequential equilibrium that issuers with current shareholders take-up t , such that $t \leq \min\{t_{2pp}, t_{2ir}\}$ and $t \geq t_{2b}$, follow the flotation path $\{pp, ir, ur\}$.²¹*

The two concerns in choosing flotation methods are the direct cost and the wealth losses. Given a low take-up, a low equity selling price will lead to wealth losses, no matter what type of issues a good firm uses. A good firm will have incentives to undergo inspection so as to correct the market's belief and raise the selling price. Therefore, pp, ir dominate ur . Between pp and ir , when the take-up is low enough, the additional losses from selling equity to outside investors in private placements become relatively unimportant compared with the direct cost saved. Therefore, private placements will be chosen.

Eckbo-Norli proposition 3: *It is part of a pooling sequential equilibrium that issuers with current shareholder take-up t , such that $t \leq \min\{t_{3pp}, t_{3ir}\}$ and $t \geq t_{3b}$, follow the flotation path $\{ir, pp, ur\}$.*

As in proposition 2, when take-up is low, good firms prefer to undergo inspection in order to raise equity selling prices. pp, ir dominate ur . In the choice between pp and ir , since take-up is not so low, it is better for a good firm to employ rights offers to reduce

²¹ In proving this proposition, Eckbo-Norli do not check the incentive constraints of bad firms. However, they may be binding since pp is employed by good firms to signal quality and bad firms may be unwilling to assume this signalling cost.

the losses from selling under-priced equity to outside investors. Therefore, ir is preferable to pp .

There may be overlapping among the ranges of t where each of $\{ur\}$, $\{pp, ir, ur\}$ and $\{ir, pp, ur\}$ can be equilibrium. To choose among overlapping equilibriums, Eckbo-Norli propose to choose the equilibrium with lowest expected cost. They further establish the issue choice on the entire range of t :

Eckbo-Norli proposition 4: *There exists take-up level t_{4pp} and t_{4ir} , with $t_{4pp} < t_{4ir}$. $\{pp, ir, ur\}$ is a Pareto dominant equilibrium for issuers with $t < t_{4pp}$. For $t \in [t_{4pp}, t_{4ir}]$, $\{ir, pp, ur\}$ is Pareto dominant equilibrium. For $t > t_{4ir}$, $\{ur\}$ is Pareto dominant equilibrium.*

When take-up level is high enough ($t > t_{4ir}$), the wealth losses to outside investors for a good firm is trivial if the firm chooses rights offers. And since the direct cost of uninsured rights offers is lower than that of insured rights offers, uninsured rights offers will be the optimal choice.

When take-up is at median level ($t \in [t_{4pp}, t_{4ir}]$), the wealth losses become a concern even for firms choosing rights offers. A good firm has incentives to undergo quality tests to correct the market price and reduce the wealth losses from underselling its equity. Insured rights offers dominate private placements in this range. The reason is that since investigation is not perfect, a good firm passing the test will still be under-priced. Wealth losses are still an important concern. Given a median take-up level, insured rights offers can effectively limit the wealth losses comparing with private placements. Therefore, insured rights offers are the dominant choice.

When take-up level is low enough ($t < t_{4pp}$), private placements dominate rights offers. Since take-up is low, a good firm has incentives to signal quality and therefore will undergo quality tests. Private placements dominate insured rights offers in this range. The reason is that given a low take-up, the gains from rights offers in limiting wealth losses is small. On the other hand, the direct cost of private placements is lower compared with insured rights offers. Therefore, private placements are the dominant choice.

Note that in this equilibrium, asymmetric information is not resolved with a firm's choice of flotation methods. Since the equilibrium is pooling, all firms in the same take-

up range follow the same flotation-choice sequence. However, the market can infer a firm's type with both the firm's take-up level and its flotation choice. With these information, the market can infer the firm's performance in the quality tests, e.g. if a firm has a median take-up level and the firm choose private placements, the market can infer that this firm has failed in a test before.

1.4 Agency cost and control approach

Agency cost and control approach explains the SEOs price effects by reconsidering the notion that managers will maximize a firm's value. An essential feature of public companies is the separation of ownership and control. The preferences of managers and owners generally will not coincide. Incentive provision is necessary for managers to behave optimally from owners' point of view. It has long been recognized that market for corporate control can provide incentive for managers to behave well through take-over threats. How well the threats can discipline managers depends on a firm's capital structure. Shleifer and Vishny (1986) shows that a tender offer is more likely to arise and succeed if the raider holds a substantial share of the firm at the time of offer. Since equity private placements tend to create outside block-holdings, the take-over threats incumbent management faces may become substantial afterwards, which provides incentives for the management to maximize the firm's value. Therefore, equity private placements may improve a firm's value and raise its stock price.

In what follows, we first introduce the organizational features of a public firm and explain why and how agency problem can arise in the firm. We then focus on the disciplinary power from the capital market and explain why the existence of large outside shareholders can enhance this power. The main idea we want to present is that SEOs, e.g. equity private placements, can affect a firm's value through affecting the disciplinary power from capital market.

1.4.1 Some organizational features of public-traded firms

In a perfect capital market, property right theory predicts that the managers of a firm should own all the firm's assets because they have important asset-specific investment decisions to make or they have human capitals essential for the assets' use (Hart, (1995)).

However in real world, the managers are often wealth-constrained and can not buy the entire asset. Here comes the separation of ownership and (effective) control. Among firms of this type, public-traded firms are of the least restricted form in that the firms' owners (common shareholders) are not required to play any other roles and their residual claims are freely alienable without any restriction.

Due to the separation of ownership and control, agency problem arises. The preferences of managers and shareholders generally will not coincide. Firstly, managers do not assume all the residual effects of their decisions. If running a firm requires efforts and the efforts are costly to the managers, without any incentive schemes and discipline measures, they will not behave in the shareholders' optimal interest since they only obtain part of the residual surplus from their efforts. Secondly, it is acknowledged that there are private benefits from control. Managers may divert company funds for their private consumption; they may carry out unprofitable projects to build empires. With control rights, they can pursue their objectives at the expense of shareholders (Jensen and Meckling (1976), Jensen (1986)).

This incentive problem can not be solved costless-ly because complete contracting is impossible. Firstly, it is generally impossible or prohibitively costly to bargain on and lay down in the contract every future contingency and the associated action managers should take. Secondly, managers are experts who know more about the relevant aspects of decision-making. Thirdly, managers' efforts are generally not observable and can at most be imperfectly inferred from outcomes.

Despite these problems, as Alchian (1968) noted, "millions of people hand billions of their money over to managers against very limited explicit assurances their investment will be handled responsibly." This can not happen without any forces that constrain managers to behave in the optimal interest of shareholders. In what follows, we discuss the internal discipline measure in a public firm. As Holmstrom and Tirole (1989) noted, managers are also subject to the supervision by capital market, labour market and product market. For the sake of our theme, we will discuss the supervision by capital market in the next section.

The internal discipline measure includes monitoring and explicit contracting. Managerial contracts are incentive schemes which attempt to align the interests of managers and shareholders. An incentive scheme is a sharing rule of surplus. The incentive-scheme design problem for shareholders is about finding a sharing rule under which the management finds it in his interest to make a particular action that the

shareholders desire. Principal-agent models offer a theoretical paradigm within which this design problem can be studied. The general lesson is that management should be paid more the more likely the outcome conforms the view that the management make the right action.²²

At the summit of the hierarchy of a public firm, the internal (decision) monitor is performed by the board of directors. A firm's decision process can be separated into decision making and decision monitor. Decision making is the process of initiating and implementing a production decision; decision monitor is the process of ratifying a decision initiative, monitoring agents' performance in implementation, and setting rewards. Separation of ownership and (effective) control means most of the decision making rights are delegated to the management. How decision monitor is performed? A public-traded firm has diffused residual claimants (shareholders). It is costly for all of them to engage in decision monitor. Besides, most of them are not qualified to undertake this role. Therefore an efficient internal monitor system involves delegation of monitor rights. In addition, it should also involve separation of decision making and decision monitor. An individual agent should not be delegated exclusive rights on both at the same decision. To efficiently control the management, an independent control layer, called board of directors, is introduced between shareholders and management.

In a public firm, shareholders delegate all decision making rights and most monitor rights to its board of director. The board then delegates most of the decision making rights and many monitor rights to top-level management. But it retains the rights to intervene in the firm's operation including ratifying and monitoring firm's important decision, and rewarding or replacing top managers. With their votes, Shareholders retain the ultimate control on the firm, more accurately on the board, by nominating the board members and voting on some major company policies, e.g. merger and acquisition.

However, there has been criticism on the function of board in a public firm. Although board members may have a reputation to protect, they are rarely paid contingent on their performance.²³ And there has been evidence that they are closely tied to management²⁴ and thus are less likely to be too critical about its under-performance. The role of this control layer will be subject to further study.

²² Holmstrom (1979), Shavell (1979)

²³ Holmstrom and Tirole (1989)

²⁴ Mace (1971), Wu (2004)

1.4.2 Capital market discipline

A firm's shares do not merely confer its shareholders the residual income rights, but also the residual control rights. The control rights allow shareholders to replace incumbent management who behaves opportunistically or who is unable to run a firm in an optimal way, with a more efficient management team. Subject to the take-over threats from capital market, incumbent management may constrain its opportunistic behaviour and act more in the shareholders' interests.

However, the take-over mechanism may not work effectively. The motivation for a raider to take over a firm may be his private information²⁵ or his private benefits of control. Grossman and Hart (1980) show that it is difficult for a tender offer²⁶ to succeed for purely informational motives. From shareholders' point of view, any offer an outside raider makes reveal the fact that if the take-over succeeds, the firm's ex-post value will be above the value of that offer. If each shareholder considers himself non-pivotal, his dominant strategy is not to tender. Therefore, tender offers can not succeed. At ex-ante, a raider will have no incentives to monitor a firm and search for improvement. The disciplinary power from the capital market is weakened.

A solution to the take-over dilemma is by the design of dilution rights, which is to exclude free-riding shareholders from the gains in a takeover. Grossman and Hart (1980) prove that a higher right to dilute encourages raiders to invest to identify poorly run firms and indirectly provides management more incentives to behave well.

Another solution is to create or consolidate outside block-holdings of a firm. Shleifer and Vishny (1986) show that an increase in a large shareholder's holding increases the large shareholder's investment in monitors, and thus the probability of value increasing takeovers and the market value of the firm. This idea is supported by Wruck (1989). She finds that the two day announcement AAR for equity private placements is significantly positive. Since private placements tend to create large outside shareholders²⁷, the positive effects on the firms' value may come from the induced outside monitors and takeovers with the creation of large shareholders.

²⁵ For example, he may have identified a more efficient management team.

²⁶ Takeovers can occur through mergers, tender offers or proxy contests. In a merger or a tender offer, the party intending to take over the firm offers to purchase majority (50%) of the voting securities (generally common stock) from other shareholders. The difference between mergers and tender offers is that mergers are the voluntary choice by the target firm's managers and board, while tender offers are made directly to the target firm's shareholders without the approval from its managers and board. Proxy contests are mechanisms by which shareholders can change the firm's board of directors.

²⁷ Wruck (1989) documents that it is rare that managers or management related investors purchase new shares in private placements.

1.4.2.1 Monitoring by large outside shareholders

The take-over dilemma can be put in terms of a shareholder-free-riding problem. Public firms have diffused residual claimants. Monitoring management, searching for improvements and implementing the improvements are in fact public goods. An outside shareholder has to invest resources to monitor the firm's operation and identify improvements. However, he can only internalize part of the gains. Therefore, each shareholder has an incentive to free ride on others' efforts, which lead to an inefficiently low level of monitors and takeovers.

A second best solution to this free-riding problem is to create or consolidate large outside holdings of the firm (Shleifer and Vishny (1986)). Large outside shareholders benefit most from an improvement of a firm's value. Therefore, they have more incentives to monitor incumbent management and initiate take-overs than smaller shareholders and outside raiders do. Besides, they are better able to win in a corporate control contest, and thus have better ability to intervene when incumbent management does not perform well. If a corporation finance decision, e.g. an SEO, creates large outside shareholdings, it will improve the firm's value by increasing the disciplinary power from capital market. In what follows, we borrow the model Shleifer and Vishny (1986) to demonstrate why the existence of large outside shareholders is crucial for the capital market to exert disciplinary power on managements.

The model:

A firm's shares are held by a large shareholder, with α fraction of stake, and a fringe of atomistic small shareholders, with a total $1 - \alpha$ fraction of stake. The firm is run by a management team which is not related to the large shareholder.

Assume that there is no agency problem. However, the incumbent management may not be able to maximize the firm's value. Outside shareholders can invest to search for value improvements. Any possible improvements can only be implemented by removing the incumbent management. The way to gain corporate control is by a cash tender offer.

Assume that the incumbent management is passive. They do not hold any shares of the firm and do not undertake any resistance against outsider's takeover. The firm's discounted profit under the incumbent management is V . Note that the firm's value may be different from V if takeover by outsiders is possible.

The game has two stages. In the first stage, the large shareholder can choose a research intensity, I , to search for improvements.²⁸ This will cost him $c(I)$, with $c'(I) > 0; c''(I) > 0$. With research intensity I , he can find an improvement with value Z with probability I . The cumulative distribution of Z is denoted as $G(Z)$. Z is private knowledge of the large shareholder, but the distribution $G(Z)$ is common knowledge.

At the second stage, the large shareholder can decide whether to make a tender offer, and if he makes, how much premium to offer. In a tender offer, if he acquires at least 50% of shares, he gains control of the firm, in which case he can replace the incumbent management and implement the improvement. If he acquires shares less than that, the offer fails.²⁹ Small shareholders, when presented a tender offer, can choose to tender or not. Since their individual holding is insignificant, they believe that their decisions are non-pivotal.

Let's assume that the improvement plan is found, and consider the tender offer game in the second stage between the large shareholder and small shareholders.

Denote the offer premium as $p(\alpha)$, and allow it to be a function of α . Given $p(\alpha)$, for the large shareholder to offer, the following condition must be satisfied:

$$0.5Z - (0.5 - \alpha)p(\alpha) - c_T \geq 0 \quad (1.34)$$

$0.5Z$ is the large shareholder's surplus from the improvement if the offer succeed; $(0.5 - \alpha)p(\alpha)$ is the overall premium he offers to small shareholders to accumulate 50% of shares; c_T is the fixed cost of a cash tender offer.³⁰ For small shareholders to tender their shares, the premium offered has to be at least their expectation of the value of the improvement. Small shareholders form the expectation with three pieces of information: the large shareholder found an improvement plan; he can cover his cost given $p(\alpha)$; their knowledge of $G(Z)$. The first piece of information is not useful at the tender offer sub-game since the second piece of information is sufficient to imply the first piece of information. With the last two pieces of information, small shareholders will tender if and only if:

$$p(\alpha) \geq E[Z | 0.5Z - (0.5 - \alpha)p(\alpha) - c_T \geq 0] \quad (1.35)$$

²⁸ Small shareholders' individual holding is tiny. They have no incentives to monitor the firm.

²⁹ The paper assumes he can return the acquired shares to small investors, that is, no cost of failure

³⁰ For example, legal and administrative fees

Assume that small shareholders will tender when they are indifferent between tendering or not. Denote $p^*(\alpha)$ as the premium satisfied (1.35) with equality.

Substitute $p^*(\alpha)$ into (1.34). The equilibrium strategy for the large shareholder is to bid $V + p^*(\alpha)$ if Z satisfies (1.34), and no offers otherwise; that for small shareholders is to tender their shares.³¹ Rearrange (1.34) as

$$0.5(Z - p^*(\alpha)) + \alpha p^*(\alpha) - c_T \geq 0 \quad (1.36)$$

From (1.36), we can see that the premium offered may be above the realization of Z . The large shareholder can afford such a premium since he can subsidize the losses in the tender offer with the gain from his existing shares.

Shleifer-Vishny Lemma 1: *Takeover premium $p^*(\alpha)$ is decreasing in α .*

For a low realization of Z , the large shareholder actually suffers losses to those small shareholders who tender their shares. He would make such an offer since he can subsidize the losses with the gain from his existing shares. When his original holding is higher, given $p^*(\alpha)$, his losses in the tender offer is smaller, while his gain from his existing shares is higher. Therefore, he can afford to make an offer when the value of improvement Z is even lower. Small shareholders realize this and require a lower tender premium. A companion lemma will be immediate:

Shleifer-Vishny Lemma 2: *The critical value of $Z^c(\alpha)$ for the large shareholder to make a tender offer is decreasing in α .*

With these two lemmas, we can turn to the large shareholder's investment problem at the first stage. Given α , the large shareholder's ex-ante benefit from investment I is:

$$B(I, \alpha) = I \times E[\max\{0.5Z - (0.5 - \alpha)p^*(\alpha) - c_T, 0\}] \quad (1.37)$$

³¹ The above is the equilibrium with minimum bid. There could be other equilibriums depending on small shareholders' out-of-equilibrium beliefs. If small shareholders believe that when the large shareholder offers $p^*(\alpha)$, the value of improvement on average is actually above $p^*(\alpha)$, large shareholder will have to raise his bid. Put it in another way, small shareholders may believe that the choice of tender premium signals some information. However, this belief can not survive refinement. Suppose in equilibrium, the large shareholder who can profit by offering $p^*(\alpha)$ has to bid above $p^*(\alpha)$. It is common knowledge for all shareholders that he would like to offer the lowest premium regardless of the realization of Z . If he commits to offer $p^*(\alpha)$, it is for small shareholders' interest to tender their shares.

Before the realization of Z , the large shareholder has no supreme knowledge of the value of the improvement. He realizes that small shareholders, with the same knowledge, will demand the entire expected value of the improvement of their own shares. He rationally expects that he can only profit from the improvement of the value of his own shares. Therefore, (1.37) can be simplified as:

$$B(I, \alpha) = I \times (1 - G(Z^C(\alpha))) \times [\alpha \times E[Z | Z \geq Z^C(\alpha)] - c_T] \quad (1.38)$$

$\alpha \times E[Z | Z \geq Z^C(\alpha)] - c_T$ is his expected gain in a tender offer; $I \times (1 - G(Z^C(\alpha)))$ is the ex-ante probability that a tender offer will happen in the second stage.

The large shareholder's optimal choice of research intensity in the first stage is an I which maximizes: $B(I, \alpha) - c(I)$. To characterize the relation between the optimal choice of I and α , Shleifer-Vishny prove the following lemma:

Shleifer-Vishny Lemma 3: $(\alpha \times E[Z | Z \geq Z^C(\alpha)] - c_T) \times (1 - G(Z^C(\alpha)))$ is increasing in α .

This lemma says that given that an improvement plan is found, the large shareholder's expected gain is increasing with his original share holding. Although the expected value of the improvement that will be implemented is lower, the increased probability of implementation more than compensates that. Put it in another way, there is an additional range of Z which the large shareholder can benefit from when α gets higher.

The marginal benefit of research intensity, I , is

$$(1 - G(Z^C(\alpha))) \times [\alpha \times E[Z | Z \geq Z^C(\alpha)] - c_T]$$

With lemma 3, we can see that this term is increasing in α . Therefore, the optimal choice of $I^*(\alpha)$ is increasing in α .

With $I^*(\alpha)$, the firm's ex-ante value can be expressed as:

$$V(\alpha) = V + I^*(\alpha)(1 - G(Z^C(\alpha)))E[Z | Z \geq Z^C(\alpha)] \quad (1.39)$$

$I^*(\alpha) \times (1 - G(Z^C(\alpha)))$ is the ex-ante probability that a tender offer will happen in the second stage. $E[Z | Z \geq Z^C(\alpha)]$ is the expected value of the improvement if a tender offer happens. Shleifer-Vishny prove that $V(\alpha)$ is increasing in α .

Shleifer-Vishny proporsitional 1: an increase in a large shareholder's holding increases the large shareholder's investment in monitor, the probability of value increasing takeovers and the market value of the firm.

When α is higher, the large shareholder has better ability to pay for a takeover and he can implement an improvement which he can not before. Since the large shareholder can benefit from a larger set of improvements, his ex-ante incentive to identify improvements increases. Because the set of improvements that can be implemented is larger and the probability with which an improvement arises is higher, the firm's value increases.

The existence of a large shareholder is crucial for value increasing takeovers to occur. When the large shareholder holds more shares, it will be more likely that improvements arises, and it will be easier to implement an improvement in the firm. Therefore, if a transaction results in new outside block-holdings or result in size increments of existing block-holdings, the firm's value will be enhanced.

1.4.2.2 Some criticisms on the role of large outside shareholders

In the last section, we demonstrate that creation of large outside shareholdings can improve a firm's value since capital market discipline works more effectively with them. However, there have been theories that challenge the positive role of large outside shareholders. Some argue that the creation of large outside shareholdings reduces the market liquidity and thus adversely affects the informative-ness of the stock price, and therefore will reduce the information necessary to evaluate and monitor management's performance (e.g. Holmstrom and Tirole (1993)). Some argue that large shareholders' monitor not only limits managerial discretion but also depresses managers' initiatives (e.g. Burkart et al. (1997)). The others argue that large outside shareholders, with their insider information, may speculate on the stock price rather than exert efforts to monitor management (e.g. Kahn and Winton (1998)).

Holmstrom and Tirole (1993) claim that the creation of large outside shareholders will reduce the information necessary to evaluate and monitor management's performance. The existence of large outside shareholders helps firm to employ takeover mechanism to improve firm value, but it leads to low market liquidity of shares and limits the efficiency of managerial incentive contracts. Stock market plays an important role in corporate control contests. Less appreciated, it also allows managerial incentives to be provided according to the performance of share prices. Speculators, interested in trading profits,

spend resources to collect information and forecast the consequences of past managerial actions. Through trading, share price eventually incorporates speculators' information. This enables the firm to design an efficient managerial contracts contingent on share price. When the firm consolidates a large shareholding, there will be fewer shares traded and market liquidity will be lower. As in most market microstructure models, speculators will find it difficult to profit on their private knowledge. Thus, marginal value of information falls and they will spend less effort on collecting and evaluating information. Therefore, there will be less information content that can be incorporated into price and price will be less informative. As a result, managerial contracts based on share price will be less efficient. So there is trade-off between employing takeover mechanism which requires the existence of large shareholders, and incentive contract mechanism which favours a diversified ownership.

Burkart et al. (1997) challenges the value of large shareholders by arguing that large shareholders' monitor not only limits managerial discretion but also depresses managers' initiatives. Managerial discretion is detrimental to firm value ex-post, but it may be beneficial from ex-ante point of view. When manager expect that ex-post he can extract some value produced by his ex-ante effort, he will have more incentive to show managerial initiatives. As long as managerial initiative does contribute to firm value, monitor on managers is not purely beneficial. There is trade-off between gains from monitor and those from managerial initiative. Ownership structure can be viewed as a commitment device to monitor. Existence of large outside stake is a commitment to monitor and depresses managers' initiatives. Optimal ownership structure may not involve large shareholders if managerial initiative contributes a lot to firm value. Burkart et al. (1997) is consistent with the early literature on takeovers and managerial myopia (Hermalin (1987), Laffont and Tirole (1987), and Stein (1988). This literature generally agrees that too much takeovers make management value the future less than it should, and thus distort its decision-makings.

Other literature further examines large outside shareholders' incentive to monitor a firm's performance. Large outside shareholders, by monitoring management, can obtain insider information of the firm. They can actually profit on their private information by speculating in the open market. Sometimes, their incentive to speculate is consistent with

their incentive to monitor.³² But it may not always be the case. Huddart (1993) and Admati, et al. (1994) show that in an active and anonymous stock market, an already large outside shareholder may sell rather than monitor the firm. Kahn and Winton (1998) further show that when a firm's insider information is difficult to access by the public, e.g. small firms or firms in high-tech industries, profits from speculation may be of first-order importance and large outside shareholders will have less incentive to monitor; when the market has optimistic view upon a firm, large outside shareholders have less incentive to monitor since monitoring reduces the value of their private information.

1.5 Conclusion

SEOs price effects may come from the market's interpretation of a firm's decision to sell equity and the associated flotation method chosen. Asymmetric information of firms' value gives rise to an adverse selection problem in equity finance market. The market rationally expects the adverse selection problem and responds negatively to equity offers. To mitigate the adverse effects of equity offers, a firm can signal its quality to the market. The instruments for firms to signal can be equity selling prices and equity flotation methods. If signalling is differentially costly to firms of different qualities, a non-pooling equilibrium may exist. If so, firms' qualities will be revealed to the market and the market will update its valuation according to firms' signalling choices.

SEOs price effects may also come from the improved or worsened outside monitors on incumbent management. Due to the separation of ownership and control, agency problem may arise in a public firm. The capital market can curb the agency problem through take-over threats. And the threats will be more substantial when a firm's large outside shareholders hold more shares of the firm. Since an SEO may alter a firm's share-holding structure, e.g. equity private placements tend to create outside block-holdings, the take-over threats the incumbent management faces may change with the offer, which will have effects on the management's incentives to maximize the firm's value. Therefore, SEOs can affect a firm's value through affecting the disciplinary power from the capital market.

³² For example, the market believes that a firm will perform badly. The firm's large outside shareholder private observe a potential improvement. He can speculate on this private information by purchasing its stocks and implementing the improvement.

Chapter 2

Adverse Selection in London SEAQ, A Review

2.1. Introduction

London SEAQ is organized as a dealership market. Dealership markets rely on dealers to conduct price discovery and liquidity provision which are the two core functions of a stock exchange. Liquidity provision is about bridging the gap of time and quantity between demand and supply. To ensure it in a dealership market, a dealer is obligated to make tradable quote anytime during the normal trading period³³. Price discovery is about impounding information into price so that price is efficient and can be guidance for resource allocation.

In a dealership market, dealers conduct price discovery by trading with informed traders who invest in information acquisition and generate private information of a stock. With their informational advantage, informed traders speculate a stock when its price does not incorporate their private information. Their speculative behaviours impose an adverse selection problem to dealers³⁴: they buy as price is low and sell as price is high. Although dealers suffer losses in these transactions, they obtain information necessary to reevaluate a stock and update its price.

In this section, we will borrow some canonical models to investigate the process of price discovery in dealership markets. In particular, we want to answer the following questions: how market makers (dealers) infer private information with transactions; why adverse selection generates bid-ask spread in dealership markets; how the pattern of adverse selection varies with some important trading decisions, e.g. trade size and trade time, and with the organizational features of the market, e.g. automated trading or human intermediate trading. Implicitly, we only focus on in price discovery with trades.³⁵ Our object is to lay down the theoretical background for our empirical work in *Chapter 3*

³³ The normal trading period is from 8:00am to 4:30pm in London SEAQ. Before 8:00am and after 4:30pm, there exists a indicative trading period in which quotes from dealers are not tradable unless they are willing to.

³⁴ Actually, it is an extreme adverse selection. Unless sufficient liquidity trading exists, market will collapse.

³⁵ There are other mechanism to perform this function, e.g. overnight information flows, e.g. Lockwood and Linn (1990), and information sharing among market makers, e.g. Cao et al. (2000).

where we will rely on the response of price and spread to trades to detect the magnitude of adverse selection.

2.2 Adverse Selection and Bid-Ask Spread

In dealership markets, dealers are obligated to set bid and ask prices associating with a quantity, with interpretation that they are willing to sell up to that quantity at the ask and buy at the bid. In this way, dealers make liquidity. Investors can trade against dealers' quote and take liquidity.

The main question dealers concern is that some investors are better informed, and they trade because the current price is not "correct" in the sense that it does not account for their private information. Dealers suffer losses in these transactions. In order to avoid further losses, dealers have to update their quotes in response to trades. When the next investor is always better informed, which means dealers' quote is always incorrect, dealers better shut down the market since they lose all the time. However there may be liquidity traders who trade not because price is incorrect. The question is that when the two types of investors coexist, whether dealers can sustain market, and if they can, how price should be set. In what follows, we take a simple version of the model in Glosten and Milgrom (1985) to answer this question.

Competitive dealers make a market for a stock. At date t , the stock has two equally possible value, \underline{V} and \bar{V} , with $\bar{V} > \underline{V}$. Traders have two types, $\Theta = i$, or u : with probability π , a trader is of type i and informed about the stock value; with the remaining probability, he is uninformed and will trade for liquidity reasons. Assume that all traders can only trade one unit with market makers.

Market makers are obligated to make tradable quotes to the market: ask price at which they sell to a trader and bid price at which they buy from him. At date t , their unconditional expectation of the stock value is $v_t = \frac{\underline{V} + \bar{V}}{2}$. However, they will not quote this price since they can do better by making their quotes conditional on the time t order flow. Ask (bid) price is made contingent on a purchase (sale) from a trader. They rationally expect that in equilibrium an informed trader will buy if and only if the true value is \bar{V} , and will sell if and only if the true value is \underline{V} .

$$P_t^{Ask} = E_t(V_t | buy) = \bar{V} \times \Pr(\Theta = i | buy) + v_t \times \Pr(\Theta = u | buy) = \pi \bar{V} + (1 - \pi)v_t \quad (2.1)$$

$$P_t^{Bid} = E_t(V_t | Sell) = \underline{V} \times \Pr(\Theta = i | sell) + v_t \times \Pr(\Theta = u | sell) = \pi \underline{V} + (1 - \pi)v_t \quad (2.2)$$

There is a gap between the bid price and the ask price,

$$P_t^{Ask} - P_t^{Bid} = \pi(\bar{V} - \underline{V})$$

We can interpret this gap as bid-ask spread. The spread is the result of potential informed trading. If there is no informed traders, e.g. $\pi = 0$, the bid price and the ask price will be market makers' unconditional expectation of the stock value, v_t . In this sense, spread is the instrument for market makers to guard themselves against adverse selection. When the degree of adverse selection is higher, e.g. π gets higher or $\bar{V} - \underline{V}$ becomes larger, spread will be wider.

However, even with bid-ask spread, market makers still lose to informed traders. When $\pi \in [0,1]$, ask price is below \bar{V} and bid price is above \underline{V} . Market makers recoup these losses by trading with uninformed traders. At the end, what informed traders earn is exactly what uninformed traders lose. Market makers earn zero profit. This feature is consistent with another canonical model by Kyle (1985) on batch-auction market.

It is important that market makers can quote two prices in a dealership market. In this model, no any single price can ensure market makers a zero-profit. That is, the market can not exist if market makers can only quote one price.

Market makers' belief is updated after trading. At date $t+1$, their unconditional expectation of the stock value v_{t+1} is exactly P_t^{Ask} after a date- t purchase and P_t^{Bid} after a date- t sale. Their belief-update, measured by the difference between v_{t+1} and v_t , is $\pm \frac{\pi}{2}(\bar{V} - \underline{V})$ which is positively related to the degree of adverse selection.

2.3 Systematic Patterns of Adverse selection

In the above simple model, lots of informed traders' decisions are simplified away. In real world, traders with private information may attempt a sufficient large-size transaction to best exploit their informational advantages. They may time their trades when the probability of liquidity-trading is higher so that the spread they pay can be smaller. In a human intermediate market, they may even cooperate with and share private information with market makers so as to obtain a better price. All these will affect the pattern of adverse selection.

2.3.1 Trade size and adverse selection

Easley and O'hara (1987) offer a model to relate trade quantity and adverse selection. They establish a separating equilibrium where informed traders will only trade large quantity despite a worse transaction price. The idea is that an informed trader has incentive to trade large size so as to best exploit his private information. However, he may not do so because market makers rationally expect the adverse selection in the large-size market and will offer an unfavourable transaction price. But if there is sufficient liquidity-trading in the large-size market, market makers can recoup their losses to the informed by trading with liquidity traders, and price in the large-size market will be improved. If this is the case, the informed may concentrate in the large-size market. And trade size will be informative. In the follows, we simplify Easley and O'hara (1987)'s model to discuss this issue.

A stock with random value V . An Information event " e " which affects the stock value takes place. The event can be good or bad: L (bad) with probability δ ; H (good) with probability $1 - \delta$.

$$\underline{V} = E[V|e = L]$$

$$\bar{V} = E[V|e = H]$$

Multiple dealers exist in the market. They are risk neutral and homogeneous. Dealers can not observe event s . There are also a large number of risk-neutral traders. If event s takes place, a fraction of π can observe the signal and become informed.

In this model, traders are permitted to buy (sell) small size, B^1 (S^1), or large size, B^2 (S^2). $B^2 > B^1$, $S^2 > S^1$.

To sustain the market, we assume exogenous liquidity trading. If they buy, uninformed traders have probability X_B^1 to buy B^1 and X_B^2 to buy B^2 . If they sell, they have probability X_S^1 to sell S^1 and X_S^2 to sell S^2 . Because uninformed may trade both size, informed traders' identity will not be perfectly revealed.

Dealers trade for profit. They keep the market open solely because there are liquidity trading. Their unconditional expectation of the asset value is $\delta \underline{V} + (1 - \delta) \bar{V}$.

The game processes as the following: Nature decides the nature of event s . Then dealers are asked to offer price $(P_B^1, P_B^2, P_S^1, P_S^2)$ for each quantity (B^1, B^2, S^1, S^2) . A trader is

randomly drawn. He is free to trade the quantity he wants if he is uninformed, or takes the profit maximizing quotes if he is informed.

Dealers, in order to set quotes, will form expectation of the nature of the event taking into account the trader's choice.

$$\delta(C) = \Pr(V = \underline{V}|C) = 1 \times \Pr(e = L|C) + 0 \times \Pr(e = H|C) \quad (2.3)$$

$$\text{Where } C \in \{B^1, B^2, S^1, S^2\}$$

Because of competition among dealers and risk neutrality, the price for each quantity will be set at the dealers' conditional expectation of the stock value.

When price is the same for large and small size, it is clear that the informed will strictly prefer to trade large size to maximize profit. But informed traders' choice will reveal information to dealers, and dealers will offer a worse price for large size transaction. Our question is that under what conditions will the informed stick on large-size transactions. In what follows, we construct a separating equilibrium where this is the case.

Given that the informed only trade large quantity, small size trades are solely from uninformed. Given a small size trade, dealers' expectation of the probability of a bad event will be exactly their unconditional expectation of that.

$$\delta(B^1) = \delta(S^1) = \delta$$

Because a large sale to dealers may be from an informed trader, dealers increase the probability they attach to $V = \underline{V}$. Similarly, they increase the probability of $V = \bar{V}$ when they receive a large buy order.

$$\delta(S^2) = \delta \frac{\pi + X_S^2[1-\pi]}{\pi\delta + X_S^2[1-\pi]} \geq \delta \quad (2.4)$$

$$\delta(B^2) = \delta \frac{X_B^2[1-\pi]}{\pi(1-\delta) + X_B^2[1-\pi]} \leq \delta \quad (2.5)$$

π is the probability of the arrival of an informed trader. From (2.4) and (2.5), We can see that: $\frac{\partial \delta(S^2)}{\partial \pi} > 0$, $\frac{\partial \delta(B^2)}{\partial \pi} < 0$

Because of competition, the price dealers set will be the conditional expectation of the stock value given the trader's choice:

$$P_B^1 = \delta \underline{V} + (1-\delta) \bar{V} = P_S^1$$

$$P_S^2 = \delta(S^2) \underline{V} + (1-\delta(S^2)) \bar{V} < P_B^2 = \delta(B^2) \underline{V} + (1-\delta(B^2)) \bar{V}$$

For the separating equilibrium to exist, the informed must still prefer to trade a large quantity.

$$S^2[P_S^2 - \underline{V}] \geq S^1[P_S^1 - \underline{V}] \quad (2.6)$$

$$B^2[\bar{V} - P_B^2] \geq B^1[\bar{V} - P_B^1] \quad (2.7)$$

The necessary conditions for (2.6) and (2.7) are

$$\frac{S^2}{S^1} \geq 1 + \frac{\pi\delta}{X_S^2(1-\pi)} \quad (2.8)$$

$$\frac{B^2}{B^1} \geq 1 + \frac{\pi(1-\delta)}{X_B^2(1-\pi)} \quad (2.9)$$

For the separating equilibrium to exist, the probability of arrival of informed traders, π , must be sufficiently small, the uninformed must assign sufficiently high probability to trade large size, and the size difference between a large trade and a small trade must be sufficiently large.

Dealers can offer the following price schedule to sustain the equilibrium:

$$\begin{aligned} P_S(q) &= P_S^1 \text{ if } q \leq S^1 \\ &= P_S^2 \text{ if } S^1 < q \leq S^2 \\ &= \underline{V} \text{ if } S^2 < q \end{aligned}$$

Similar argument applies to buy side.

In the small-size market, there is no bid-ask spread, $P_B^1 = P_S^1$. Spread arises because of adverse selection. In this equilibrium, only liquidity traders trade small size. Market makers face no adverse selection problem in the small-size market, and thus do not need protection from spread. On the other hand, spread exists in the large-size market. And one can easily observe that equilibrium spread, $P_B^2 - P_S^2$, will be widened when adverse selection gets more severe, e.g. a higher π .

2.3.2 Trade time and adverse selection

Trade time is a choice variable for traders. Kyle (1985) considers the best strategy for a monopoly informed trader to exploit his long live information: breaking up his large informed order and spread the trades over time. Not only informed traders, liquidity traders may also time their trades strategically to minimize trade costs. From the previous sections, we can see that it is exactly liquidity traders who pay the adverse selection costs. It is of their interests to trade when the probability of informed trading is low, or to pool

with other liquidity traders to trade at the same time. Therefore, traders do not enter market randomly and adverse selection effect may have a systematic pattern.

Admati and Pfleiderer (1988) model the strategic timing by the two types of traders. Traders in their model can choose when to trade, and possibly when to become privately informed. Liquidity traders prefer to trade when market depth is high, which creates an incentive for liquidity traders to pool their trades at the same time. Informed traders also prefer to trade when market is deep, and thus will trade when liquidity traders pool their trades. If informed traders have the same information, the introduction of more informed traders intensifies the competition among themselves, and reduces their total gain from information. As a result, liquidity traders' welfare improves. This creates an additional incentive for liquidity traders to pool their trades. Information content of trades, or adverse selection, is unchanged if informed traders' private information is given exogenously. But if they can choose to be informed with a cost, information content of trades increases when liquidity traders pool their trades.

2.3.3 Human intermediation and adverse selection

The theory introduced so far is about anonymous trading markets. In a market of this type, informed traders act non-cooperatively and attempt to exploit their information advantage. Although informed trading is crucial for price discovery, it creates burdens to the rest of the market. As shown before, liquidity provision will be more costly when informed trading and thus adverse selection gets more intense. In this sense, informed trading is a public bad for an anonymous trading market: an informed trader profits with his private information while shares with other participants the cost of a worsen-market quality resulted from his trade.

Alternatively, a market can be organized as a human intermediate trading market, e.g. LSE and NYSE. The general feature of this type of markets is that a relatively small and stable group of professional traders repeatedly and un-anonymously trade with each other on a long-term basis. This feature encourages reputation building and cooperation among market participants. The reason is that repeated and un-anonymous trading makes rewards and punishments possible. A trader with private information will have less incentive to exploit his information advantage since he faces a possibility of future punishment by his trading partners, e.g. his future trades may not be accommodated by market makers or may receive a bad execution. On the contrary, he may have incentive to

share his information with other market participants since he may be rewarded for his cooperative manner, e.g. market makers offer price improvement to his order. Information sharing is possible in this market and price discovery can be conducted in a more cooperative manner: information can be impounded into price without sacrificing the quality of liquidity provision.

There have been theoretical models on the working of human intermediate markets. Garmill (1990) considers a “carrot” version of human intermediation. He argues that market makers can heighten the competition among informed traders by only offering price improvement to the first one who reveals private information. His idea is consistent with Admati and Pfleiderer (1988) where competition among the informed reduces the burden of adverse selection on liquidity traders. Lawrence, et al. (1992) considers a “stick” version of human intermediation. They argue that market makers can mitigate the effects of asymmetric information by improving price for those traders with good reputation of not harming market makers with private information. In line with Lawrence, et al. (1992), Gabriel and Thierry (2002) consider more specifically on how market makers discipline informed participants. They argue that price improvement is an incentive device for market makers to encourage reputation building so that traders do not attempt to profit on market makers with their private information. In what follows, we borrow the model in Lawrence, et al. (1992) to demonstrate the effect of human intermediation on adverse selection and the welfare implication of this type of markets.

A stock with exogenous random value. Trading occurs at discrete time, $1, 2, \dots$. With a probability π , an information event takes place before each round of trading. Only informed traders can observe it. The private information is short-lived, and will be public after each round of trading. At each round, denote the expected stock value conditional on public information as V^* . The information event will lead to revision of stock value to either $V^* + \alpha$ or $V^* - \alpha$, each with equal probability. α can be interpreted as the amount of private information.

A competitive dealer makes the market. He expects zero-profit. At each round, denote the ask and the bid prices he sets as: $P^{Ask} = V^* + s^{Ask}$, $P^{Bid} = V^* - s^{Bid}$. Assume symmetry of bid ask, $s = s^{Ask} = s^{Bid}$. “ s ” can be interpreted as (effective half) spread.

Liquidity traders trade to satisfy exogenous liquidity needs. They have downward sloping demand and upward sloping supply:

$$Q_d(s) = q^* - \zeta(P^{Ask} - V^*) = q^* - \zeta s \quad (2.10)$$

$$Q_s(s) = q^* + \zeta(V^* - P^{Bid}) = q^* - \zeta s \quad (2.11)$$

The variables q^*, ζ are common knowledge.

Informed traders trade for profit. To avoid infinite trading, we put an upper bound, q_i , on the size of informed traders' aggregate order at each round of trading.

Anonymous trading market

In a market of this type, trading is anonymous. The dealer is passive in the sense that he does not try to discretion between informed traders and liquidity traders. This implies he will sets a single ask price and a single bid price.

At the beginning of each round, the dealer set bid-ask prices. After observing the quotes, informed traders and liquidity traders submit their orders to the dealer.

Given that the dealer set spread s , his revenues from liquidity traders are: $R(s) = 2s(q^* - \zeta s)$. His losses to informed traders are: $C(s) = \pi q_i(\alpha - s)$. Zero profit condition requires $R(s) = C(s)$.

Denote this pooling-equilibrium spread as s_p :

$$s_p = \frac{q^*}{2\zeta} + \frac{\pi q_i - [(\pi q_i + 2q^*)^2 - 8\alpha\pi q_i\zeta]^{1/2}}{4\zeta} \quad (2.12)$$

s_p is a function of π, α, q_i, q^* . It is increasing in π, α, q_i , because they represent the probability of informed trading, the advantage of private information and the scale of informed trading. A larger spread is required when adverse selection gets more severe. s_p is decreasing in q^* which represents the scale of liquidity trading.

The pooling spread may not be Pareto efficient. If there exists a spread pair (s_l, s_i) which satisfies $s_l < s_p, s_i < s_p$, and $C(s_i) \leq R(s_l)$, the pooling spread is inefficient and there will room for Pareto improvement in which both types of traders pay a smaller spread while the dealer maintain a non-negative profit. The inefficiency of the pooling spread comes from the sensitivity of liquidity trading to the size of spread. An increment of spread always reduce the dealer's losses to the informed, but it may not always increase his profits from liquidity traders. When spread is above $\frac{q^*}{2\zeta}$, increasing spread actually reduces $R(s)$. Put in another way, an increment in spread may not always

enhance dealers' ability to sustain the market since their ability to pay the informed traders may be lower.

Lawrence, et al. (1992) proves that pooling spread is inefficient if and only if $R'(s_p) < 0$, which is equivalent to $s_p > \frac{q^*}{2\zeta} = s_{\max}$. This will be the case if and only if $\alpha > s_{\max} [1 + \frac{q^*}{\pi q_i}]$. This condition will be satisfied if adverse selection is too severe or the scale of liquidity trading is too small.

Lawrence, et al. (1992) further proves that given $\pi > 0$, there always exists α for which a pooling equilibrium exists and is inefficient. This implies that there is always possibility of efficiency losses in an anonymous trading market. In what follows, we will show how human intermediation can improve upon it.

Human intermediate market

In this section, a broker is introduced into the market. The broker, through repeated trading with investors, possesses better information of them. He can help the dealer to distinguish the informed from the uninformed. The dealer provides incentive for the broker to tell truth with his punishment strategies.

The game processes as following: the dealer, at the beginning of each round, set two prices: s_l, s_i , one for liquidity traders and the other for the informed. Traders submit orders to the broker. The broker observes a noisy signal about each order's type. He then submits the orders to the dealer and chooses whether to report the signals he receives. The dealer, according to the signal the broker reports, offer the corresponding price to each order. At the end of each round, the dealer, with a positive probability, receives perfect signals about the signals the broker received, and then decides whether to punish him.

Denote the probability with which the signal the broker receives is correct as σ . Since a signal with $\sigma = 0.5$ is totally uninformative, assume $1 \geq \sigma \geq 0.5$. Denote the probability that the dealer receives the signal the broker received as γ .

We will focus on the truth telling separating equilibrium of this game. In this equilibrium, the dealer offers two different sets of prices, and the broker chooses to tell the truth.

After the dealer announce s_l, s_i , traders rationally anticipate that their perceived identity will be truthfully reported by the broker, but will be misrepresented with probability $1 - \sigma$. The expected terms of trades for the two types of traders are:

$$s_l^e = \sigma s_l + (1 - \sigma) s_i \quad (2.13)$$

$$s_i^e = \sigma s_i + (1 - \sigma) s_l \quad (2.14)$$

Their trading decisions will be $2(q^* - \zeta s_l^e)$ for liquidity traders, and q_i for informed traders.

From the dealer's post, the expected profit from traders is:

$$2s_l^e(q^* - \zeta s_l^e) - \pi q_i(\alpha - s_i^e) \quad (2.15)$$

Zero profit condition requires (2.15) to be equal to zero.

Informed traders' participation constraint is: $s_i^e \leq \alpha$. Liquidity traders participate when $q^* > \zeta s_l^e$.

Given any s_l, s_i such that $s_l \neq s_i$, the broker has an incentive to lie to the dealer. If $s_i > s_l$, when he perceives the trader as an informed one, he has incentive to report the trade as a liquidity trade. The reason is that the trader can save a cost equal to $s_i - s_l$ if the broker reports his trade as uninformed one, and the broker can extract part of this gain. On the other hand, if $s_i < s_l$, the broker has incentive to report a perceived liquidity trade as an informed trade since doing so can encourage liquidity trading and he can earn more commissions.³⁶

We believe that the truth-telling equilibrium should have the feature that $s_i > s_l$. In a properly organized market, liquidity costs should be controlled at a low level. Besides, liquidity trading is sensitive to s_l in this model. As discussed before, a large s_l may be detrimental to the market.

Given that $s_i > s_l$, the dealer has to provide an incentive for the broker to tell the truth when the broker observes an informed trades. Assume that the broker has all the bargaining power and can extract all the gains from strategically misreporting, $s_i - s_l$. To sustain truth telling, the dealer's strategy should be able to wipe out all the broker's gain from misreporting. Lawrence, et al. consider the following strategy: if the dealer find that the broker misreports, he will punish the broker by offering a bad price in the next N

³⁶ The issue of commission is not formally modelled. However, the validity of the following discussion will not be affected.

uninformed orders³⁷. That is, he will charge a spread s_i . Assume that the broker is in a competitive brokerage industry. If he is punished, to maintain his business, he has to pay the penalty $s_i - s_l$ himself when he receives an order from a perceived liquidity trader.

In equilibrium, the following condition must be satisfied:

$$s_i - s_l \leq \gamma[N(s_i - s_l) + c] \quad (IC)$$

c represents an additional punishment by the dealer. Lawrence, et al. interpret it as the cost of under-provision of facility.³⁸ Apparently, the above IC constraint will be satisfied with a sufficiently large N .

To compare the welfare implication of the two types of markets, Lawrence, et al. (1992) establish that given the same market parameter, the expected spread liquidity traders pay in the human intermediate market never exceeds the pooling spread in the anonymous trading market; if pooling equilibrium in the anonymous trading market exists and is inefficient, human intermediate market can achieve Pareto improvement when the dealer has sufficient ability to sanction the broker's opportunistic behaviour, e.g. γ or c is sufficiently large.

As in the previous section, the pooling equilibrium in an anonymous trading market may be inefficient when adverse selection is too intense. Human intermediation can improve efficiency in the sense that liquidity traders and informed traders can both get better execution. The idea is that when adverse selection is too intense, in an anonymous trading market, market makers have to set a wide spread to guard against informed trading. Since liquidity trading is sensitive to the size of spread, market makers' profits from liquidity traders may drop. And this will impair market makers' ability to organize the market which results in an even wider spread. Adverse selection creates heavy burden to a market of this type.

However, in a human intermediate market, because of the separation of informed orders and liquidity orders, the conflict between price discovery and liquidity provision is mitigated. Liquidity traders can enjoy a low cost of liquidity provision and become more active. Market makers may profit more from liquidity traders and become less vulnerable to informed trading. If so, both types of traders can enjoy a better execution quality in a human intermediation market.

³⁷ In the punishment phrase, the broker has incentive to report any orders as liquidity ones. But this may trigger further punishment. However, Lawrence, et al. has no discussions on this issue.

³⁸ E.g. do not share information with the broker. However, this issue can not be discussed with the current model.

2.4 Conclusion

In London SEAQ, dealers conduct price discovery by trading with informed traders. Informed traders speculate a stock when its price does not incorporate their private information. Their speculative behaviours impose an adverse selection problem to dealers. The adverse selection problem forces dealers to update their valuation of a stock. The magnitude of the update is positively related to the degree of adverse selection.

Dealers suffer losses from trading with informed traders. Spread arises to compensate dealers for the losses. When adverse selection gets more severe, dealers suffer more losses to informed traders and spread gets wider.

Adverse selection may have systematic patterns. Informed traders may attempt a sufficient large-size transaction to best exploit their informational advantages. They may time their trades when the probability of liquidity-trading is higher so that the spread they pay can be smaller. Therefore, the degree of adverse selection may relate to trade size and trade time. Human intermediation may effectively separate the market into an informed-trade market and a liquidity-trade market. Thus, adverse selection may concentrate in a market segment which is under market makers' control.

Chapter 3

Detect information content of trades in LSE with application to examine the Signalling Hypothesis in the SEOs Literature

3.1 Introduction

Right issues were almost the only SEOs method employed in the UK before the late 1980s. After that, companies have increasingly opted to issue equity with private placements. One of the frameworks in which an equity private placement takes place in the UK is known as an open offer. It is a hybrid of private placement and rights issue. Before an open offer is publicly announced, new shares are placed to a small group of investors. However, current shareholders retain the rights of first refusal, and they can 'claw back' their entitlement from the placees. But if they do not take up, they can not sell the rights. Therefore, wealth transfers will occur if offer price is set at discount which happens most of the time in practice. Take-up rates are generally low in UK open offers (Armitage and Snell (2003)).

Most of the research in UK SEOs, e.g. Slovin, et al. (2000), document negative announcement price effects of rights offers when alternative issue methods are available. Despite being priced at substantial discount, UK open offers elicit positive market reaction (Armitage (2002) and Armitage and Snell (2003)), which is consistent with the finding for private placements in US, e.g. Wruck (1989), Hertz and Smith (1993). The literature posits two sets of theories to explain the price effects of various issue methods. The first and most prevalent one suggests that the price effects of private placements and open offers come from the new outside block-holdings the offers create. These block-holders can partially internalise a firm's gains from their monitoring efforts and thus have incentive to monitor the firm's performance. The presence of these new block-holders

increases the possibility of value-increasing takeovers. Therefore, market responses positively to private placements and open offers.

The second set of theories study the price effects in a context of asymmetric information. A firm's value is not known by public. But it can costly signal its quality with its choice of SEOs methods since a flotation method is differential costly to firms of different qualities. If signalling results in a non-pooling equilibrium, then asymmetric information is resolved or partially resolved, and post-issue stock-price effects occur. In the placing process of UK open offers and private placements, potential placees will investigate the issuers and decide whether to buy (Armitage (2002)). Issuers of different qualities are differentially able to pass the investigations, with high quality issuers being better able to. Thus, high quality issuers may employ private placements or open offers to signal quality (Armitage and Snell (2003)). If so, market will respond positively to open offers and private placements.

There have been lots of empirical researches, e.g. Wruck (1989) and Cronqvist and Nilsson (2000), on the first set of theories, referred to as agency costs and control approach. They provide evidences that private placements enhance the disciplinary power from capital market so that agency problem of management is better controlled. Although some empirical works are devoted to the second set of theories, e.g. Hertzal and Smith (1993), and Wu (2005), they do not test directly the hypothesis of private placements as a signalling device. For example, they find that firms with high degree of asymmetric information are more likely to employ private placements (Wu (2005)), and the abnormal returns post equity private placements are positively related to the degree of asymmetric information (Hertzal and Smith (1993)). We contend that their findings do provide some evidences for the signalling hypothesis, but are not sufficient. Firstly, they have not established that firms of high degree of asymmetric information suffer negative market responses when choosing other SEOs methods. Secondly, the choice problem for firms with low degree of asymmetric information is missing in their discussion. The role of private placements for these firms is not clear. Thirdly, to identify the degree of asymmetric information, they employ some proxies, such as firm ages and existence of venture capitalist in the firm's IPO, which, although is reasonable, can not be perfectly rationalized. And most of these proxies are invariable even though the degree of asymmetric information changes during SEOs.

This thesis intends to provide firm evidences for the signalling hypothesis. In the context of UK open offers and rights offers, we attempt to establish that good firms signal quality with open offers.

If good firms do signal quality with open offers, asymmetric information of firms' values must be resolved with equity offers. The reason is that the market can observe a firm's choice of flotation methods and can infer the firm's quality from its choice. Thus insider information will be revealed to the market with equity offers.

To examine the resolution of asymmetric information, we can rely upon transactions in the secondary market. If asymmetric information of a firm's value is resolved, the amount of private information about the firm is reduced. As a result, in the secondary market, informed traders' informational advantage over market makers is lessened. Adverse selection in the transactions of the firm's stock will be less severe.

Therefore, the hypothesis of resolution of asymmetric information can be tested by identifying the changes of adverse selection in the secondary market transactions during equity offers. Negative changes suggest that asymmetric information is resolved with equity offers.

In section 3.5, with price impact method, we find that information content of trades marginally significantly falls after both rights offers and open offers. This result suggests adverse selection gets less severe post equity offers. And it in turn implies that asymmetric information is resolved with equity offers. Together with Armitage and Snell (2003)'s finding of positive price effects of UK open offer and negative price effects of rights offers, our result suggests that asymmetric information is resolved with firms' choices of equity flotation methods, and that open offers are employed by good firms to signal quality to the market.

To provide evidence for the signalling hypothesis, the main hypothesis to test is that asymmetric information is resolved with equity offers. An essential ingredient for this test is a measure of the degree of adverse selection in the secondary market transactions. Microstructure literature posits that the degree of adverse selection can be revealed with the size of spreads and the magnitude of the impact of trades on prices (Glosten and Milgrom (1985)). Based on that, empirical methodologies, such as simple spread comparison (e.g. Kothare (1997)), decomposing spread models (e.g. Huang and Stoll (1997)) and price impact methods (e.g. Holthausen, Leftwich and Mayers (1987)), have been devised to measure the degree of adverse selection. In this thesis, we will start with

some simple methods and then move on to more delicate methods to test the hypothesis of resolution of asymmetric information.

The thesis is organized as follows. In section 3.2, descriptive statistics for offer characteristics, firm characteristics, trading characteristics and spread characteristics are provided. In particular, we are interested in the changes in spreads during equity offers. Since spreads compensate market makers for their losses to informed traders, we expect the size of spreads to fall during equity offers if asymmetric information is resolved.

In section 3.3, we run regressions of spreads on a set of variables known to be unrelated to adverse selection. The spread changes unrelated to the changes in adverse selection may be controlled for with the regressions. And the changes in the residual spreads during equity offers may be a result of changes in adverse selection. If asymmetric information is resolved, we expect the residual spreads to fall during equity offers. Besides, we investigate the explanatory power of firm size, price level, volume and volatility on the cross-sectional variation of percentage spreads, and on the cross-sectional variation of changes in percentage spreads.

In section 3.4, we employ decomposing spread models to directly identify the spread component related to adverse selection. The spread literature contends that spreads have three components: order processing cost component (Demsets (1968)), inventory holding component (Stoll (1981)) and adverse selection component (Glosten and Milgrom (1985)). Order processing cost creates the bid-ask bounce with order inflows, while the other two components do not. Adverse selection component is incorporated into spreads in a forward looking way, while inventory holding component is in a backward looking way. The decomposing spread models in Glosten and Harris (1988), Huang and Stoll (1997) and MRR (1997) are constructed based on these features of the three cost components. However, these decomposing spread models fail to produce sensible results with our data-set. We contend that this may be due to the high degree of human intermediation in London SEAQ. A critique of the application of this methodology in human intermediated markets will be provided.

In section 3.5, we employ price impact method to identify the degree of adverse selection. A trade has temporary impact and permanent impact on price. The degree of adverse selection can be measured by a trade's permanent impact on price. If asymmetric information is resolved with equity offers, permanent impacts of trades should fall during equity offers. Besides, we will investigate the pattern of adverse selection in London SEAQ. Adverse selection may be related to trade size (Easley and O'hara (1987)).

Human intermediation, which is an important feature of London SEAQ, may effectively separate informed trades with liquidity trades and thus may affect the pattern of adverse selection (Lawrence, et al. (1992)). Adverse selection may be asymmetric between block purchases and block sales (Gemmell (1996), and Keim and Madhavan (1996)). We will investigate these issues with the measure of adverse selection obtained with the price impact method.

Section 3.6 concludes.

3.2 Data and Descriptive Statistics

3.2.1 Sample description

A sample of UK open offers and rights offers is obtained from Professor Seth Armitage and Professor Andy Snell. The sample of open offers consists of 148 offers in London stock exchange with announcement date from June 1998 to August 2001. That of rights offers consists of 88 offers with ex-rights date from July 1998 to July 2001. In the sample of rights offers, all except 2 offers are insured-rights offers. This is consistent with the sample characteristics in Slovin, et al. (2000). Professor Seth Armitage also provides us the information about the announcement date (the ex-rights date), the offer price (the subscription price), the number of shares outstanding and the number of new shares issued for each open offer (right issue).

For stocks in our sample, we search for their transaction data in London stock exchange Transaction-Data-Service. We use an issuer's name to identify the tradable instrument code of its common stock. According to it, we search all transaction records and quote records in a period of 41 trading days surrounding the announcement day (ex-rights day for right issues). We include a stock only if its transaction data and its market makers' quote data are available in the database. Our sample is now limited to 107 open offers and 31 rights offers.

For each stock in the final sample, we pick up its transaction data and quote data in the 41-day event period according to its tradable instrument code. Transaction data includes trade time, trade price, trade quantity, buy-sell indicator, trade type indicator, publication indicator, price format indicator and market segment code for every transaction. Quote data includes the best bid-ask prices and the time when a best bid-ask starts to be effective. Since trade data and quote data are recorded separately in the data base, we match each trade with the quote prevalent when the trade took place. Although

publications of trades with sizes above 3 NMS are not immediately, dealers accommodating or facilitating the trades are required to report immediately to the exchange the details of transactions including the time when the trades are executed. Therefore, the delay of publications does not make the matching problematic.

Through out data searching, we found that almost all stocks in our sample are traded in dealership market (SEAQ and AIM). To eliminate the influence from the organizational form of the markets, we exclude the stocks traded in SET or SETmm. Our final sample contains 100 open offers and 29 rights offers. All the right offers are insured rights offers.

3.2.2 Descriptive Statistics for Firm Characteristics

In this section, some descriptive statistics on offer characteristics and firm characteristics are generated to illustrate the features of the two types of offers. In particular, we focus on the ratio of new shares issued over total shares, gross proceeds from equity offers, issuers' market value, the ratio of gross proceeds over issuer's market value, offer discounts and offer prices. We find that in our sample, rights offer firms are generally larger than open offer firms; rights offers are on average larger than open offers in that the proceeds from offers are larger; new shares in rights offers are sold generally at a higher price than those in open offers. Table 1 summarizes the mean and median statistics. T statistics for difference in mean between the two types of offers are provided.

For the open offers, the mean and the median of the ratios of new shares over total shares post offer are 24.7% and 20% respectively. For the rights offers, the mean and the median are 22.6% and 20% respectively. Although the mean ratio of the open offers is above that of the rights offers, the difference is not significant.

The mean and the median gross proceeds for open offers are £18 million and £10 million respectively. In Hertz and Smith (1993) on US private placements, the mean and the median gross proceeds are \$11.4 million and \$5.4 million. The size of our open offers is larger than their private placements. The Mean and the median of gross proceeds in our rights offers are £156 million and £22 million. Slovin et al. (2000) reports the mean and the median gross proceeds as £74 million and £27.5 million in their UK insured rights sample. Our median is similar with that in Slovin et al. (2000), but our sample contains some large offers which push up the mean. Eckbo and Masulis (1992) report a mean of \$60.4 million and a median of \$21.6 million in US insured rights offers. Compared with US rights offers, British rights offers are on average larger. The mean and

the median gross proceeds of our rights offers are both above those of our open offers. T test for the difference in the mean gross proceeds between them has a one-sided P-value of 13%, which is marginally significant.

For our open-offers stock, the mean and the median ratios of gross proceeds to firms' market value are 34% and 25% respectively.³⁹ The mean and the median ratios for our rights-offers stocks are 25% and 20%.⁴⁰ Both the mean and the median ratio of our open-offers stocks are higher than those of our rights-offers stocks. T test for the difference in the mean has one sided P-value 6%. Since the gross proceeds in our rights offers are on average larger than those in our open offers, it suggests that the firms choosing rights offers are larger than those choosing open offers.

Issue discount is calculated as $\frac{P_{-1} - P_e}{P_{-1}}$. P_e is the exercise price and P_{-1} is the closing mid-point in secondary market the day before the announcement (ex-rights day) of equity offers. The mean and the median issue discounts for our open offers are 16% and 9.5%. As in Wruck (1989), we find that some firms' shares are placed at premiums. The maximum premium in our sample is 350%, which is larger than that (100%) in Wruck (1989)'s sample.⁴¹ The mean and the median private placement discounts in Hertz and Smith (1993) are 20% and 13%, which is similar to ours. The mean and the median subscription discounts in our rights offers are 20% and 19%. 3 firms' shares are issued at premium, with maximum premium of 8%. It is strange that a rights offer is issued at premium, since investors can purchase shares in the secondary market. But taking into account the transaction cost (the bid-ask spread) in secondary market transactions, it is still sensible for some rights offers to be priced at slight premiums. Slovin et al. (2000) reports the mean and the median discounts of 17% and 16% in their insured rights offer sample. Eckbo and Masulis (1992) report the mean and the median discounts of 20.4% and 19.5% in their US insured rights offer sample. Both results are similar to ours. T test for the difference in the mean discount between our open offers and rights offers has one sided P value of 12%. The discount in our rights offers is larger than that in our open offers at a marginal significance level.

³⁹ Market value is measured as the multiplier of pre-offer outstanding shares and the average trade price from event day -20 to -1.

⁴⁰ Slovin et al. (2000) reports a mean and a median ratio of 40% and 20% for their insured rights offers.

⁴¹ Xenova Group plc made a placing and open offer on July 13, 2000. The offer price was 345p per unit. The closing mid point in secondary market the day before announcement was 76.5p. The offer premium was 351%.

The mean and the median market values of our open-offer firms are £126 million and £38 million. Herztel and Smith (1993) report a mean and median of \$95 million and \$46 million in their US private placement sample. Wu (2005) reports those of \$93 million and \$51 million in his US private placement sample. Our UK open offer firms are larger than their US private placement firms. The mean and the median market value of our rights offer firms are £934 million and £130 million. This confirms that our rights-offer firms are larger than our open-offer firms. T test for the difference in the market value between our two types of issuers has one sided P value 0.14, which is marginally significant. Slovin et al. (2000) reports those of their UK insured rights firms of £324 million and £111 million. Our median is similar with theirs, but our mean is about 3 times larger than theirs. This implies that our rights offer sample contains some offers made by very large firms.

The mean and the median of the offer prices of our open-offers stocks are £2.2 and £0.75. Those of the subscription price of our rights-offers stocks are £4.2 and £2.8. T test for the difference in mean has one sided P value of 0.03. The new shares of our rights offer firms are priced significantly higher than those of our open offer firms.

3.2.3 Descriptive Statistics for Spread and Trading Characteristics

In this section, descriptive statistics for spreads and changes in spreads is generated. Spread is the compensation to market makers for providing liquidity. One of the components of spreads is the adverse selection cost component (Glosten and Milgrom (1985)). It is the compensation to market makers for trading with informed traders. If asymmetric information is resolved with equity offers, adverse selection will become less severe post equity offers and market makers will suffer fewer losses to informed traders. Therefore, the adverse selection cost component of spreads should fall. Assume that the other cost components of spreads do not change. We should observe that spreads get smaller after rights offers and open offers.

We also provide descriptive statistics for price level, volume and volatility of the two types of stocks. Statistical tests are carried out to test the difference of trading characteristics between the two types of stocks, and for each type of stocks, the difference between pre-offer period and post-offer period.

3.2.3.1 Data Filter

We focus on the trading period of 41 days surrounding the offer announcement (ex-rights) day. The pre-offer trading period is from day -20 to day -1; the post-offer trading period is from day 1 to day 20. For each stock, there is a sequence of trades and a sequence of best bid-ask quotes. Each trade is matched with the best bid-ask effective when it took place. Since some trades and quotes did not reflect the nature of liquidity provision and price discovery, we set up the following filter for trades and quotes:

1. Trades without firm quotes are eliminated. London SEAQ's daily trading period starts at 7:30am and ends at 5pm. From 7:30am to 8:00am, the market is run with indicative quotes from market makers (indicative quoting period). Market makers are not obligated to quote, and if they quote, the quotes are not firm. That is, these quotes are not tradable unless the market maker is willing to. Cao et al. (2000) suggest that market makers share information among themselves in this period. They signal the direction in which price should move to other market makers by crossing and locking the inside quotes. Price discovery is conducted without trades. At 8:00am, the market enters into normal trading period. Each market maker is required to enter firm quotes. A trader can have his order executed at these quotes without uncertainty given that his order is below the quote size. At 4:30pm, the market turns again into indicative quoting period. Firm quotes reflect market makers' beliefs of asset value, while indicative quotes may be just an instrument to acquire and transfer information. It is inappropriate to use indicative quotes to evaluate market makers' beliefs of the informational characteristics of the associated trades. Thus, trades without firm quotes are eliminated.
2. Quotes that are not firm are eliminated. Although not reported, we do find some cases in the indicative quoting period where inside quotes are locked. When inside quotes are locked, there is no bid-ask spread. But this does not reflect the quality of liquidity provision since these quotes are not tradable. In less extreme cases, spread may be small in the indicative quoting period. But again, this may be related to something other than market quality.
3. Trades between market makers are eliminated. Market makers organize the market by entering firm quotes and accommodating traders' orders. They need to hold inventories of a stock. After transactions, their inventory holding may be away from the optimal level. To reverse his holdings back to the optimal, a market maker can trade with other market makers in the Inter-Dealer-Broker market. Tonks and Snell

(1998) find that the execution quality of these trades is usually good. This may be due to the long-term relation among market makers, or may be because it is desirable for them to trade with each other since their inventories move in opposite direction. The execution quality of these trades does not reflect market quality.

4. Trades where market makers buy above mid-point or sell below mid-point are eliminated. Market makers can accommodate a trade by trading as principle, or facilitate a trade by trading as agent. Execution quality of principle trades reflect market quality, while that of agency trades is result of bilateral bargaining between trading counter parties and may not relate to market quality. Unfortunately, we lost the information about a trade's type as principle or agency trade when we collected the data. However, with a small experiment sample, we find that the execution prices of agency trades are weird and unacceptable to market makers: traders buy below mid-point or sell above it. Therefore, we eliminate trades with such characteristics.
5. Trades with trade-type label "B", "X", and with publication label "C", "X" are excluded. Trades with "B" are broker to broker trades. We exclude them for the same reason we exclude trades between market makers. Trades with "C" and "X" are trades that cancelled later on.

3.2.3.2 Descriptive Statistics for Spreads

Table 2 summarizes the changes in proportionate bid-ask spreads around issue announcement date (ex-rights date) for our open offer stocks (rights offer stocks). Spreads are the main transaction costs traders assume in stock exchanges. It can be a measure of quality of liquidity provision. We employ four measures of proportionate spread: proportionate quoted spread, time weighted proportionate quoted spread, proportionate effective spread and volume weighted proportionate effective spread. Proportionate quoted spread for stock i is defined as:

$$(\%)Quoted\ Spread_i = \frac{\sum_{j=1}^{N_i^q} (ask_{ij} - bid_{ij}) / mid_{ij}}{N_i^q}$$

N_i^q is the number of quotes of stocks i during event time; bid_{ij} and ask_{ij} are the bid-ask prices of the j th quote; mid_{ij} is the associated mid point. This simple average may not accurately reflect the spreads traders pay since it is possible that small spreads only

persist for a short time, while equilibrium spreads are large. We use time weighted (%) spread to conquer this problem. It is defined as:

$$Time\ (\%)Quoted\ Spread_i = \frac{\sum_{j=1}^{N_i^Q} (ask_{ij} - bid_{ij} / mid_{ij}) \times t_{ij}}{\sum_{j=1}^{N_i^Q} t_{ij}}$$

t_{ij} is the time for which j th quote persists.

In a dealership market, trades may not always take place at quoted prices. There can be price improvements where trades are executed inside the best bid-ask. Price improvement is an instrument for market makers to discriminate between those traders who have market power and those who do not (Rhodes-Kropf (2005)), and an incentive device to encourage reputation building so that traders do not attempt to profit on market makers with their private information (Gabriel and Thierry (2002)) and to encourage traders' information sharing with market makers (Garmill (1990)). A quoted price is an ambiguous indicator of market makers' trading interests, and can not capture the possibilities of price improvements. A more accurate indicator is the actual transaction price. This give rise to two other spread measures.

$$(\%)Effective\ Spread_i = \frac{\sum_{k=1}^{N_i^T} \frac{|P_{ik} - mid_{ik}|}{mid_{ik}}}{N_i^T}$$

The above is the proportionate effective spread for stock i . N_i^T is the number of trades of stock i . P_{ik} is the trade price of the k th trade; mid_{ik} is the associated mid point. Volume weighted proportionate effective spread is defined as:

$$(\%)Volume\ Effective\ Spread_i = \frac{\sum_{k=1}^{N_i^T} (|P_{ik} - mid_{ik}| / mid_{ik}) \times V_{ik}}{\sum_{k=1}^{N_i^T} V_{ik}}$$

V_{ik} is the volume of k th trade of stock i .

For each spread measure, we take simple average across stocks. Label the four overall average spread measures as *volume (%) effective spread*, *(%) effective spread*, *time (%) quoted spread* and *(%) quoted spread*.

The *volume (%) effective spread* of our open offer stocks decreases insignificantly from 6.8% before issue announcement date to 6.5% after, with 46% of the firms experiencing

decreases. The proportion is not significantly different from 50% by binomial test Z statistics. The mean log-ratio of the spread changes is also insignificant. For our rights offer stocks, the *volume (%) effective spread* increases insignificantly from 4.28% before ex-rights date to 4.34% after, with 52% stocks experiencing increases. The proportion is not significantly different from 50%. The mean log ratio of the spread changes is insignificant.

The *(%) effective spread* of our open offer stocks increases insignificantly from 6.5% before announcement date to 6.6% after, with 53% experiencing increases. The proportion is not significantly different from 50%. The mean log-ratio of the spread changes is insignificant. The *(%) effective spread* of the rights offer stocks decreases insignificantly from 4.3% before ex-rights date to 4.1% after, with 55% stocks experiencing decreases. The proportion is not significantly different from 50%. The mean ratio of spread changes for these stocks is also insignificant.

The *time (%) quoted spread* of the open offer stocks increases insignificantly from 7.2% before announcement to 7.8% after. The mean log-ratio of spread changes is insignificant. Although the average change in spreads is insignificant, the proportion of the open offer stocks experiencing changes is significant, with 62% of stocks experiencing increases in spread. The *time (%) quoted spread* of the rights offer stocks increases insignificantly from 4.79% before ex-rights date to 4.8% after, with 59% of stocks experiencing increases. The proportion is not significantly different from 50%. The mean log-ratio of spread changes is also insignificant.

The *(%) quoted spread* of the open offer stocks increases insignificantly from 7.6% before to 7.8% after. 59% of these stocks experience increases, which is not significantly different from 50%. The mean log ratio of spread changes is also not significant. *(%) quoted spread* of the rights-offer stocks increases insignificantly from 4.8% before to 5% after. 55% of these stocks experience increases, which is not significantly different from 50%. The mean log-ratio of spread changes is also insignificant.

Overall, we find little evidence of spread changes after open offers and rights offers. Although the spreads of our open-offer stocks increase in 3 out of 4 measures, the changes are insignificant. The proportion of our open-offer stocks experiencing increases in spreads are above 50% in all four spread measures, but only in one measure, the proportion is significantly different from 50%. For the rights-offer stocks, spreads increase in 3 measures and the proportion of stocks experiencing increases is above 50%.

But none of these changes are significant and none of the proportion measures are significantly different from 50%.

Our finding contrasts with Kothare (1997). He finds that US rights offer stocks experiences significant increases in spreads during equity offers. He argues that rights offers tend to increase the concentration of a firm's ownership structure and thus reduce liquidity trading of the firm's stock. Trade orders are more likely from informed traders. Dealers have to increase spreads to guard themselves against the informed. Although Kothare (1997) finds that ownership concentration is higher in his sample, the literature on SEOs contends that a rights offer generally does not alter a firm's ownership structure since new shares are offered on pro rata basis. Reduction of liquidity trading post rights offers may not be universally true.⁴²

Difference-in-mean tests show that our rights-offer stocks have significantly smaller spreads than our open offer stocks do in all four spread measures. Benston and Hagerman (1974) and Stoll (1978) show that proportionate spreads are negatively related to price, trading volume and firm size, and are positively related to the risk of a security. In our sample, the rights offer firms are on average larger than the open offer firms, and have higher share prices (summarized in *Table 3*). These may contribute to the relatively smaller spreads of our rights offer stocks.

For both our rights-offer stocks and our open-offer stocks and both the pre-offer and the post-offer period, the two quoted-spread measures are larger than the two effective-spread measures. This implies that quoted spreads tend to overstate liquidity cost. Price improvement is possible in human intermediate markets, e.g. London SEAQ. Long-term trading relation between market makers and market participants encourages reputation building. The incentive provision takes the form of price improvements.

3.2.3.3 Descriptive Statistics for Trading Characteristics

Table 3 summarizes trading characteristics of the two type stocks in the pre-offer and the post-offer period. A stock's price level is measured by the average mid point during an event period. Average price level of our open-offer stocks in the pre-offer period is £2.27; that of our rights offer stocks is £4.82. A difference-in-mean test shows that in the pre-offer period, our rights-offer stocks on average have stock prices significantly higher than our open-offer stocks. Average price of our open-offer stocks in the post-offer

⁴² Actually his finding of increase in dollar volume post rights offer may be inconsistent with reduction of liquidity trading.

period is £2.31; that of our rights-offer stocks is £4.86. A difference-in-mean test again shows that our rights-offer stocks on average have significantly higher prices.

The average number of trades per day is 31 in the pre-offer period, and 34 in the post offer period for an open offer stock in our sample. That for a rights offer stock is 20 in the pre-offer period, and 19 in the post-offer period. Although the open-offer stocks on average have more trades than the rights-offer stocks in both pre and post offer period, the difference is not significant.

The average number of shares traded per day in the pre-offer period is 257 thousand for an open-offer stock, and 290 thousand for a rights offer stock. Post equity offers, the number of shares traded per day for an open-offer stock rises to 381 thousand, while that for a rights-offer stock drops to 179 thousand. The activeness of trading seems to change in different directions for the two types of stocks.

The average pound volume per day for an open-offer stock is £256 thousand in the pre-offer period and £273 thousand in the post-offer period. That for a rights-offer stock is £402 thousand pre-offer and £547 thousand post-offer. The rights-offer stocks have higher volume than the open-offer stocks both pre and post offer. However, difference in mean tests show that the difference is not significant.

Volatility is measured by the standard variation of mid point during an event time. The average volatility of our open-offer stocks is 0.206 pre-offer and 0.212 post-offer. That for our rights-offer stocks is 0.272 pre-offer and 0.431 post-offer. The rights-offer stocks on average seem to be more risky than the open offer stocks, but tests show that the differences in mean are not significant.

Table 4 summarizes the changes of trading characteristics during equity offers for the two types of stocks. This time, we employ paired difference tests. For each type of stocks, we calculate the mean log-ratio of changes in the above trading-characteristics measures: price level, the number of trades per day, shares traded per day, volume per day and volatility. We also count the proportion of stocks experiencing increases in each measure.

Trading seems to be more active post open offers, as the mean log ratios of changes in the number of trades, the number of shares traded and pound volume are positive. However, none of these changes are significant. 54% of stocks experience increases in the number of trades; 57% experience increases in the number of shares traded; 56% experience increases in pound volume. But none of these proportions are significantly different from 50%.

For the rights-offer stocks, there is little evidence that trading activity becomes more active or less active post offers. None of the mean log ratios of changes in the number of trades, number of shares traded and pound volume is significant. The proportions of stocks experiencing increases in these measures are no different from 50%.

The mean log ratios of changes in mid prices are insignificantly negative for both types of stocks. 57% of our open offer stocks experience price drops post equity offers, which is not significantly different from 50%. 76% of our rights offer stocks experience price drops. The proportion is significantly different from 50%. Thus, we have a minor evidence of the post-rights-offer price falls which are widely documented in the literature, e.g. Slovin et al. (2000) and Eckbo and Masulis (1992).

The mean log ratio of changes in volatility is positive for the open-offer stocks, and is negative for the rights-offer stocks. But both are insignificant. 59% of the open offer stocks experience reduction in volatility. The proportion is marginally significant. Since volatility of a stock's price can be a proxy for the amount of private information of the stock, this may suggest some resolution of asymmetric information with equity open offers. 55% of the rights-offer stocks experience reduction in volatility. The proportion is not significantly different from 50%.

We also test whether the changes in mean log ratios are different between the two types of stocks. We find that there is some difference in the changes of volatility. While volatility of the open-offer stocks tends to be lower post offer, the price of our rights-offer stocks seems to be more volatile. The difference is 95% significant with one sided P-value. This may suggest that there is resolution of asymmetric information with equity open offers, but not with rights offers. However, since volatility is a noise measure of asymmetric information, whether resolution of asymmetric information does occur with equity offers will be subject to further investigations.

3.2.3 Summary for Section 3.2

For all the 4 spread measures, we find that spreads do not experience significant changes during rights offers or open offers. Since spread compensates market makers' losses to informed traders, our finding suggests that the degree of adverse selection does not change post equity offers and thus there is no resolution of asymmetric information with equity offers.

For all the 4 spread measures, Rights offer stocks have significantly smaller spreads than open offer stocks do in both event periods. Benston and Hagerman (1974) and Stoll (1978) show that proportionate spreads are negatively related to price level. Since our rights offer stocks have significantly higher stock prices than open offer stocks do in both event period, the smaller spreads of rights offer stocks may be a result of higher stock prices.

Quoted spread measures, time weighted or not, are larger than effective spread measure, volume weighted or not. This suggests that transaction prices are better than quoted prices. Quoted spread measures tend to exaggerate trading costs in London SEAQ where trades are often human intermediated and price improvements are possible.

In our sample, rights offer firms on average have higher market values than open offer firms do. Compared with those of our open offers, the proceeds of our rights offers are larger; offer prices are higher; offer discounts are larger.

For both types of stocks, trading volume and volatility do not experience significant changes during equity offers. Right offer stocks seem to experience post-offer price falls. There is no significant difference between trading volume and volatility between the two types of stocks. Rights offer stocks on average have a higher price level than open offer stocks do.

3.3 Spread regressions

Our main hypothesis is that asymmetric information is resolved with equity offers. If this is true, spreads should be smaller post equity offers since market makers suffer fewer losses to informed traders. However, the result in Section 3.2 shows that spread does not change after open offers or rights offers, which is not consistent our hypothesis.

Another possibility is that although market makers reduce spreads for lower adverse selection, for some other reasons they increase spreads so that spreads as the whole do not change. The spread literature suggests that spreads consist of three components: order processing cost component (Demsetz (1968)), inventory holding component (Stoll (1981)), and adverse selection component (Glosten and Milgrom (1985)). Adverse selection component is the part of spreads which compensates market makers' losses to informed traders. It is possible that although adverse selection component falls, the other two components rise such that the sum of the three does not change. In order to identify

the change of adverse selection component, we must control for the factors that affect the other two components.

In this section, we propose two regression models to net out the changes in spreads due to the change in adverse selection. We regress the 4 spread measures obtained in the last section on variables related to order processing cost component and inventory holding component to obtain the residual spreads. If the residual spreads change during equity offers, the changes may probably be induced by the changes in adverse selection since the changes in other cost components have been controlled for. If the residual spreads of both types of stocks significantly fall during equity offers, it may suggest resolution of asymmetric information.

3.3.1 Methodology

Previous empirical works on spreads suggest that proportionate spread is negatively related to firm size (Barclay (1997)), trading volume (Stoll (1978)) and price (Bessembinder (1997)), and positively related to volatility (Benston and Hagerman (1974)). Firm size can be a proxy of market liquidity, and affects market makers' inventory holding cost. Trading volume is a measure of activeness of trading. When a market maker's inventory holding deviates from optimal level, the probability that he can reverse his holding back to optimal through trading depends on the activeness of trading. As a result, inventory holding cost will be higher when trading volume is lower. Volatility is a measure of the risk-ness of a security. High volatility implies frequent inflow of private information. Thus volatility is positively related to adverse selection component.

To capture the change in adverse selection component during equity offers, we propose the following two spread-regression models⁴³:

$$\begin{aligned} Spread(\%) = & \beta_0 + \beta_1 \ln(Firm\ size) + \beta_2 \frac{1}{Price} + \beta_3 \ln(Trading\ Volume) \\ & + \beta_4 \ln(Volatility) + \beta_5 D_P + \beta_6 D_R + \beta_7 D_{PR} + \varepsilon \end{aligned} \quad (a)$$

$$\begin{aligned} Spread(\%) = & \beta_0 + \beta_1 \ln(Firm\ size) + \beta_2 \frac{1}{Price} + \beta_3 \ln(Trading\ Volume) \\ & + \beta_5 D_P + \beta_6 D_R + \beta_7 D_{PR} + \varepsilon \end{aligned} \quad (b)$$

⁴³ We admit that the relation between inverse of price and percentage spread lacks of economic justifications. In the appendix, we provide another set of estimations in which the variable for the inverse of price is not included. The results lead us to the same conclusion: no resolution of asymmetric information.

Each firm contributes two sets of observations: the pre-issue and the post-issue observations. Firm size is measured by a firm's market capitalization. A firm's market capitalization is the number of shares outstanding multiplied by the average price level of those shares in an event period. The information about the issuers' outstanding shares is provided by Professor Seth Armitage. Note that in the post issue period, the new equity raised is included to determine a firm's market capitalization. Price is measured by the average mid point of transactions during the 20-day trading period. Trading volume is measure by the pound volume per trading day. Volatility is measured by the standard variance of mid points of transactions.

Firm size, trading volume and volatility are in log form since previous literature suggests log transformation provides better fit (e.g. Barclay (1997)). D_p is the dummy variable for the post-offer observations (0 for pre, 1 for post). D_R is the dummy for the rights-offer observations (0 for open offers, 1 for rights offers). D_{PR} is the interactive dummy between D_p and D_R .

D_p is designed to capture the change in spreads for the open-offer stocks during equity offers; D_{PR} is to capture that for the rights-offer stocks. After we control for order processing cost and inventory holding cost, β_5 and $\beta_5 + \beta_7$ may indicate the spread changes induced by changes in adverse selection.

Our main hypothesis is that asymmetric information is resolved with equity offers. When asymmetric information is resolved, adverse selection will be less severe. If so, the adverse selection component of spreads should fall post equity offers. Therefore, the hypothesis can be tested by,

$$H_0 : \beta_5 = 0 \text{ or } \beta_5 + \beta_7 = 0, \text{ or both (Asymmetric information is not resolved)}$$

$$H_1 : \beta_5 < 0 \text{ and } \beta_5 + \beta_7 < 0 \text{ (Asymmetric information is resolved)}$$

We will rely on specification (b) to test the hypothesis. In specification (a), we include all the factors related to spreads to examine their effects. However, volatility is a measure of information flows and may contaminate our measure of changes in spread induced by the change in adverse selection. Therefore we exclude it from specification (b).

While specification (a) and (b) are good in explaining the cross-sectional variation of spreads, we are more interested in the change in spreads during equity offers. Specification (c) and (d) are better at this issue:

$$\Delta Spread = \beta_0 + \beta_1 \Delta Firm\ size + \beta_2 \Delta Price + \beta_3 \Delta Volume + \beta_4 \Delta Volatility + \varepsilon \quad (c)$$

$$\Delta Spread = \beta_0 + \beta_1 \Delta Firm\ size + \beta_2 \Delta Price + \beta_3 \Delta Volume + \varepsilon \quad (d)$$

The change of a variable is measured by the log of $\frac{Variable_{Post}}{Variable_{Pre}}$. Recall that in our descriptive statistics, the mean spread change is insignificant. But again, this does not immediately imply that the spread change induced by changes in adverse selection is insignificant. To extract the information-related-spread change, we need to control for those changes related to order processing component and inventory holding component. Changes in firm size, price level and volume will be used to net out the spread changes we want.

Each firm contributes one set of observations. For each specification, we separately run regressions for the rights-offer stocks and the open-offer stocks. The constant terms may measure the spread changes related to adverse selection. Our main hypothesis can be tested with specification (d) by:

$$H_0 : \beta_0^{Open} = 0 \text{ or } \beta_0^{Right} = 0, \text{ or both (Asymmetric information is not resolved)}$$

$$H_1 : \beta_0^{Open} < 0 \text{ and } \beta_0^{Right} < 0 \text{ (Asymmetric information is resolved)}$$

3.3.2 Results for Specification (a) and (b)

Table 5 presents the regression results for specification (a) and (b). First we focus on the specification (a). For all four measures of spread, coefficients for firm size, inverse of price, volume and volatility have the signs predicted by the microstructure literature. Larger firm sizes are associated with lower percentage spreads; higher stocks prices are associated with lower percentage spreads; higher trading volumes are associated with lower percentage spreads; higher volatility of stock prices is associated with higher percentage spreads. Except the coefficients for volatility, all the coefficients for firm size, volume and inverse of price are significant at least at 90%. Volume seems to be the most powerful variables in explaining the cross-sectional variation of spreads (%). R^2 is around 50% which is similar with the previous results in the spread literature, e.g. Barclay (1997) and Bessembinder (1997). And these variables seem to have better ability

to explain quoted spreads than effective spreads since R^2 is higher in the quoted-spread regressions.

Of coefficients for volatility, an interesting feature is that they are significant in our regressions of quoted spreads, but not in those of effective spreads. Quoted spread is an instrument for market makers to guard themselves against informed trades. This notion is supported by our regressions of quoted spreads which suggest that market makers for stocks of higher risk quote wider spreads. But because of human intermediation, transactions may not always take place at quoted prices. From the regressions of effective spreads, the relation between volatility (risk) and effective spread is not significant. This implies that actual transaction prices are less influenced by adverse selection than quoted prices are. With the fact that transaction prices are better than quoted prices⁴⁴, this suggests human intermediation alleviates adverse selection problem and facilitate liquidity provisions.

We now turn to specification (b) to test our main hypothesis:

$$H_0 : \beta_5 = 0 \text{ or } \beta_5 + \beta_7 = 0, \text{ or both (Asymmetric information is not resolved)}$$

$$H_1 : \beta_5 < 0 \text{ and } \beta_5 + \beta_7 < 0 \text{ (Asymmetric information is resolved)}$$

In the regression results for specification (b), the coefficients for firm size, inverse of price and volume still have the correct signs, and are significant at least at 90%. The spread changes that originally are captured by volatility will now be captured by D_P, D_{PR} .

From table 5, only in one regression, β_5 has a sign consistent with the hypothesis. All β_5 in the four regressions are insignificant. Only in one regression, $\beta_5 + \beta_7$ has a sign consistent with the hypothesis, but in this case, β_5 's sign is not correct. All $\beta_5 + \beta_7$ are insignificant. Therefore, we accept the null hypothesis: asymmetric information is not resolved with equity offers.

3.3.3 Results for specification (c) and (d)

We first focus on specification (c) where all the factors related to spreads are included. The result is presented in panel A, table 6. The coefficients for changes in firm size, changes in price level, changes in volume and changes in volatility have the signs predicted by microstructure theory in almost all regressions. When a firm's size goes up, transaction cost of its stock goes down; when stock price goes up, proportionate spread

⁴⁴ The results in Section 3.2 suggest that effective spreads are smaller than quoted spreads.

goes down; when trading of a stock becomes more active, its spread gets smaller; when a stock becomes more risky, its spread gets larger.

However, these coefficients are not as significant as before. Changes in firm size and changes in volatility have no substantial explanatory power in this specification. Almost all of their coefficients are insignificant. Together with the result of specification (a) and (b), this suggests that firm size and volatility are powerful in explaining the cross-sectional variation of spreads, but for a specific stock, the changes of spreads are not significantly related to the changes of them. When market makers quote prices and decide the transaction prices, they may have formed beliefs about the nature of the potential private information of a stock and the liquidity characteristics of it. They may revise their beliefs according to certain variables. But from the regression, it seems that firm size and volatility are not the candidates.

Price changes and volume changes remain to have substantial explanatory power. Most of their coefficients are significant. Significantly negative coefficients of price changes suggest that when price goes up, market makers do not enlarge spreads, or at least do not enlarge it to accompany the price increases. This may be a result of competition between market makers. Volume seems to be an important variable for market makers to update their beliefs about a stock's liquidity characteristics. A stock becomes more liquid when trade volume is higher. And the risk of holding non-optimal inventories is lower. Therefore, market makers ask for less compensation and spreads fall.

To test the main hypothesis, we turn to specification (d). The result is presented in Panel B, table 6. The coefficients for firm size, price level and volume are similar with those in specification (c). We then focus on the constant term. Firstly, only in 2 regressions of the rights-offer stocks, the constants have signs consistent with the hypothesis. The constants in all regressions of the open-offer stocks have positive signs, which is inconsistent with the hypothesis. Besides, none of the constants are significant. This suggests that there are no significant changes in proportionate spreads after we control for the changes not related to adverse selection. This leads us to accept the null hypothesis: asymmetric information is not resolved with equity offers.

3.3.4 Summary for Section 3.3

After we control for variables related to order processing cost component and inventory holding component, we do not find any significant spread changes during equity offers. This suggests that asymmetric information is not resolved with equity offers.

Firm size, inverse of price and volume have significant explanatory power on the cross-sectional variation of all the 4 percentage spread measures. Larger firm sizes are associated with lower percentage spreads; higher stocks prices are associated with lower percentage spreads; higher trading volumes are associated with lower percentage spreads.

Volatility has significant explanatory power on the cross-sectional variation of the 2 percentage quoted spread measures, with higher volatility, wider quoted spread. Volatility can be a measure of information inflows. Higher volatility implies a higher probability of informed trades. Our result confirms the notion that quoted spread is an instrument for market makers to guard themselves against informed trades.

However, volatility has no significant explanatory power on the cross-sectional variation of the 2 percentage effective spread measures. Because of human intermediation, transactions may not always take place at quoted prices. Our result suggests that actual transaction prices will be less influenced by adverse selection. With the fact that transaction prices are better than quoted prices, this suggests human intermediation alleviates adverse selection problem and facilitate liquidity provisions.

Changes in firm size and changes in volatility have no explanatory power on the changes of spreads during equity offers. On the other hand, price changes and volume changes remain to have substantial explanatory power. Significantly negative coefficients of price changes suggest that when price goes up, market makers do not enlarge spreads, or at least do not enlarge it to accompany the price increases. This may be a result of competition between market makers. Volume seems to be an important variable for market makers to update their beliefs about a stock's liquidity characteristics. A stock becomes more liquid when trade volume is higher. And the risk of holding non-optimal inventories is lower. Therefore, market makers ask for less compensation and spreads fall.

3.4 Decomposing Bid-Ask Spread

In section 3.3, we do not find any significant spread changes during equity offers after we control for factors related to order processing cost component and inventory holding component. However, this result should be taken with cautions. In the spread regressions,

we try to control for factors not related to adverse selection in order to extract the spread changes relevant. So far, we can only identify factors like firm size, price level and volume. It is possible that some factors we have not identified systematically increase spreads during equity offers, and therefore even though asymmetric information gets lower, we do not observe a fall of spreads.

In this section, we will attack the question by directly identifying the degree of adverse selection. Decomposing spread model in Madhavan et al. (1997) will be employed to directly identify the adverse selection cost component of spreads. If equity offers resolve asymmetric information, the adverse selection cost component should fall post equity offers. However, from the estimation results we find no evidence of resolution of asymmetric information. Moreover, the estimations produce some incredible coefficients which can not be rationalized. At the end of this section, we offer some possible reasons for why the decomposing spread models do not work for London SEAQ.

3.4.1 Overview of the Spread Theory

The spread literature contends that spreads have three components: order processing cost component (Demsets (1968)), inventory holding component (Stoll (1981)) and adverse selection component (Glosten and Milgrom (1985)).

Traders' trading interests are different in dimension of time and size. They may not obtain liquidity immediately due to lack of opposite-side trading. To facilitate continuous trading, market makers commit to match traders' demand and supply in those two dimensions by accommodating traders' trading interests. Market makers should be compensated for the costs incurred in this liquidity-provision process. Demsets (1968) refer to this cost as order processing cost. To provide liquidity, market makers have to hold inventories. Portfolio theory predicts that they should have an optimal holding of inventory. However, trading with traders will drive their holdings away from the optimal. And they will incur undiversified risk, which will not be rewarded. This loss will ultimately be born by traders. Stoll (1981) refers to this cost as inventory holding cost. Informed traders play an essential role in price discovery process as they produce and impound information into market. The way they do so is by trading with market makers. While trades from informed traders are essential to the efficiency of stock exchange, it imposes direct losses on market makers: Informed traders buy exactly as price is lower than "true" price and sell as price is higher than that. Eventually, market makers will transfer

the losses to (liquidity) traders. This cost for traders is referred to as adverse selection cost (Glosten and Milgrom (1985)). These three cost components give rise to the existence of spreads.

To test our main hypothesis, we need to extract adverse selection cost component from spreads. To do so, it is necessary to understand the relation between transaction price and market makers' valuation of an asset, and how each cost component affects this relation. First ignore the inventory holding component and adverse selection component. Denote market makers' valuation of a security given all the public information as V . Denote order processing cost as c . Since market makers will ask for compensation c in a trade, they will not buy or sell the security at price V . Instead, they will buy from traders at price $V - c$ (bid price), and sell to them at $V + c$ (ask price). Denote the order inflow as Q ($Q=1$ traders buy from market makers; $Q=-1$ traders sell). Then the transaction price can be expressed as $V + cQ$.

Market makers understand that the value of the security may not be V since their valuation is formed without private information. Informed traders have access to the private information, and they can profit with the information advantage. Market makers believe that on average they will lose i to a trader due to his possibility of being informed. i is the adverse selection cost component and is positively related to the possibility of informed trades. Since market makers can make order contingent quotes, they can quote regret-free prices by incorporating i into bid and ask price separately. Ask price will be $(V + i) + cQ$, and bid price will be $(V - i) - cQ$. While in above, we interpret i as the losses of market makers to informed traders, a more intuitive interpretation is that i is their beliefs about the difference between the true value of the security and their current valuations when they receive a order.

The last component to incorporate is inventory holding component. If inventory holding cost is ignored, market makers' current valuation of the security is exactly at the mid price (mid point of bid-ask price). However, when inventory holding cost is considered, the mid price may not indicate their valuation. When inventory deviates from optimal holdings, market makers have incentive to reverse it back: they want to sell if they hold too much and want to buy if they fall short of it. To encourage liquidity traders to trade in the desirable direction, market makers can reduce the gap between ask (bid) price and their valuation, and enlarge that between bid (ask) and their valuation, if they

hold too much (fall short) and want to sell (buy) (Stoll (1981)). Therefore, inventory holding cost can drive the mid price away from market makers' valuation.

Order processing cost creates the bid-ask bounce with order inflows, while the other two components do not. Adverse selection component is incorporated into spreads in a forward looking way, while inventory holding component is in a backward looking way.

The decompose spread models in Glosten and Harris (1988), Huang and Stoll (1997) and MRR (1997) are constructed based on the above theories. The most important difference among these models is the different specification of market makers' information revealing strategy. In MRR (1997), and Huang and Stoll (1997), the strategy is based on trade time; in Glosten and Harris (1988), it is based on trade size. Even in MRR and Huang-stoll, the strategies are different: in MRR, market makers infer information from future trades; in Huang-stoll, they infer information from past trades. Huang-stoll is the only model that attempt to distinguish between order processing component and inventory component. To do so, they also specify market makers' inventory-reversal strategy. In what follows, we first describe the construction of these models and then apply them to our analysis.

3.4.2 Decompose spread models

3.4.2.1 Huang and Stoll (1997)

Market makers' valuation update is driven by two sources: (1) Public information shock which is not associated with trading; and (2) the trade flow last period which may reveal relevant information about the asset value.

$$V_t = V_{t-1} + \varepsilon_t + \alpha \frac{S}{2} Q_{t-1} \quad (3.1)$$

S is the average spread. α is the fraction of spread attributed to adverse selection component. Equation (3.1) implies that market makers consider the possibility of informed trading and will adjust their belief according to the last period trade direction.⁴⁵

For market makers' information revealing strategy, Huang-stoll posits that it is the unexpected trade flows that reveal information. There are many sources causing serial covariance between successive order flows, e.g. inventory holding component can induces order flows of a certain direction. Huang-stoll claim that if an order flow is in the

⁴⁵ However, it seems that market makers' behaviour is not optimal in this model. Instead of utilizing only past order flow, they can actually form valuation with future order flows since they can quote order contingent prices (Glosten and Milgrom (1985)). Bid ask prices should not only be ex-ante efficient, but also ex-post efficient.

expectation of market makers, it should have no effects on their valuation of the asset. The unexpected trade flow last period can be expressed as $Q_{t-1} - E(Q_{t-1}|Q_{t-2})$. Q_{t-1} is the actual trade flow last period. $E(Q_{t-1}|Q_{t-2})$ is the expected trade flow last period:

$$E(Q_{t-1}|Q_{t-2}) = -\pi Q_{t-2} + (1-\pi)Q_{t-2} = (1-2\pi)Q_{t-2} \quad (3.2)$$

π is the probability of trade flow reversal (the probability of continuation is $1-\pi$). With equation (3.1) and (3.2), market makers' valuation updating process can be expressed as:

$$V_t = V_{t-1} + \varepsilon_t + \alpha \frac{S}{2} [Q_{t-1} - (1-2\pi)Q_{t-2}] \quad (3.3)$$

Given the existence of inventory holding costs, market makers will adjust the bid-ask price relative to their valuation to induce inventory equilibrate trades when their inventory holding deviates from the optimal level. The distance between quoted mid point and their valuation is the part of spread set up to equilibrate inventory.

$$M_t = V_t + \beta \frac{S}{2} \sum_{i=1}^{t-1} Q_i \quad (3.4)$$

M_t is the quoted mid point for time t trade. β is the fraction of spread attributed to inventory component. $\sum_{i=1}^{t-1} Q_i$ is the actual inventory holding before time t transaction.

Assume a constant spread, the actual transaction price will be half of effective spread above or below the quoted mid point.

$$P_t = M_t + \frac{S}{2} Q_t \quad (3.5)$$

In the original model, there is a random term in (3.5) for rounded error. Since LSE allows for decimal trading, we can ignore the rounded error. Combining equation (3.3), (3.4) and (3.5), the change of transaction prices between subsequent periods can be put as:

$$\Delta P_t = \frac{S}{2} Q_t - (1-\alpha-\beta) \frac{S}{2} Q_{t-1} - (1-2\pi)\alpha \frac{S}{2} Q_{t-2} + \varepsilon_t \quad (3.6)$$

Equation (3.6) can be estimated by a simple linear regression.⁴⁶

3.4.2.2 Madhavan, Richardson, and Roomans, (1997)

MRR (1997) do not estimate the proportion of spreads attributable to each cost component. Instead, it estimates directly the compensation to market makers for

⁴⁶ π can be estimated separately by a linear regression: $Q_t = (1-2\pi)Q_{t-1} + \varepsilon$

processing order, holding inventory and trading with informed traders. Unlike Huang and Stoll (1997), spread is not involved in the model. But it can be recovered by summing up all the compensations to market makers.

Denote two forms of compensations to market makers as:⁴⁷

θ : Per trade loss to informed traders. It can also be interpreted as the permanent impact of unexpected trade-flows on market maker's valuation.

ϕ : Cost per trade for supplying liquidity (it includes order processing cost and inventory holding cost)

Market makers' valuation update can be expressed as:

$$V_t = V_{t-1} + \theta(Q_t - E[Q_t|Q_{t-1}]) + \varepsilon_t \quad (3.7)$$

We can see that in the MRR model, market makers are allowed to use future information to form their belief. This is consistent with the microstructure literature, e.g. (Glosten and Milgrom (1985).

MRR lump order processing cost and inventory holding cost component into a category called cost per trade for supplying liquidity. Transaction price is determined by,

$$P_t = V_t + \phi Q_t \quad (3.8)$$

Combining (3.7) and (3.8) yields,

$$P_t = V_{t-1} + \theta(Q_t - E[Q_t|Q_{t-1}]) + \phi Q_t + \varepsilon_t \quad (3.9)$$

With equation (4.9), we have $V_{t-1} = P_{t-1} - \phi Q_{t-1}$. Putting it back to (3.9) yields,

$$\Delta P_t = (\theta + \phi)Q_t - \phi Q_{t-1} - \theta E[Q_t|Q_{t-1}] + \varepsilon_t \quad (3.10)$$

The only unobservable term in (3.10) is the expected trade flow given the last period trade. As in Huang and Stoll (1997), the expected trade flow can be calculated as:

$$E[Q_t|Q_{t-1}] = (1 - 2\pi)Q_{t-1} \quad (3.11)$$

For simplicity, denote $1 - 2\pi$ as ρ , and interpret it as probability of trade continuation.

Combining (3.10) and (3.11), we have

$$\Delta P_t = (\theta + \phi)Q_t - (\phi + \rho\theta)Q_{t-1} + \varepsilon_t \quad (3.12)$$

With ρ , we can determine ϕ, θ from regression (3.12).⁴⁸ θ may be interpreted as the adverse selection cost component; ϕ may be interpreted as the order processing cost and

⁴⁷ MRR (1997) lump order processing cost and inventory holding cost component in one category. The reason they can not decompose these two cost components is that they do not use the relation between quoted mid point and market makers' valuation.

⁴⁸ ρ can be estimated separately by a linear regression: $Q_t = \rho Q_{t-1} + \varepsilon$

inventory holding cost component. According to the definition of effective spreads, we can recover the effective spread from (3.12) by setting $Q_t = 1, Q_{t-1} = 0$. The effective half spread is $(\phi + \theta)$.

3.4.2.3 Glosten and Harris (1988)

The most important difference between Glosten and Harris (1988) and the above two models is that GH emphasizes on information revelation with trade sizes, while the other two models assume fixed order size. As MRR, GH does not estimate the proportion of spreads attributable to each cost component, but directly estimates the cost per trade for each cost consideration.

The market makers' valuation update in GH is:

$$V_t = V_{t-1} + \theta_t Q_t + \varepsilon_t \quad (3.13)$$

θ_t , as that in MRR, is the cost due to adverse selection in time t transaction. As we stated above, it is expected to be a positive function of order size. Note that while θ is constant in MRR, it is time varied in GH because of the variation of order size across trades. To allow for the relation between cost and size, GH specifies a linear relation between θ_t and order size O_t :

$$\theta_t = z_0 + z_1 O_t \quad (3.14)$$

O_t is the size of time t trade. z_1 allows for the possibility that adverse selection cost is a positive linear function of trade size; z_0 allows for the possibility small trade is initiated by informed traders.

Equation (3.13) is similar with (3.7) in MRR except that belief update in (3.13) is driven by trade flow and size, but not the unexpected trade flow.

Transaction price is set by taking into account the cost of liquidity provision:

$$P_t = V_t + \phi_t Q_t \quad (3.15)$$

ϕ_t is the cost due to provision of liquidity in time t transaction. ϕ_t includes order processing cost and inventory holding cost in transaction t .

GH also specifies a linear relation between ϕ_t and order size:

$$\phi_t = c_0 + c_1 O_t \quad (3.16)$$

Equation (3.16) allows for economies or diseconomies of scale in liquidity provision. Combining (3.13-3.16), transaction price can be expressed as:

$$P_t = V_{t-1} + (z_0 + z_1 O_t) Q_t + (c_0 + c_1 O_t) Q_t + \varepsilon_t \quad (3.17)$$

Price change between subsequent trades is:

$$\Delta P_t = c_0 (Q_t - Q_{t-1}) + c_1 (O_t Q_t - O_{t-1} Q_{t-1}) + z_0 Q_t + z_1 O_t Q_t + \varepsilon_t \quad (3.18)$$

c_0, c_1, z_0, z_1 can be uniquely identified from regression (3.18). The effective half spread at time t transaction can be recovered by $\theta_t + \phi_t$.

To make the model parsimonious, GH suggests doing a model specification search. Microstructure theory, Easley and O'hara (1987), suggests that a small trade is unlikely to be initiated by an informed trader and it should have little impact on market makers' valuation. This implies that in equation (3.15), the constant z_0 should be zero and slope z_1 should be positive.

Theories do not offer much insight about how the cost of liquidity provision varies with trade size. Empirical evidence in Glosten and Harris (1987) find that $c_1 = 0$. And this gives rise to a more parsimonious model for estimations:

$$\Delta P_t = c_0 (Q_t - Q_{t-1}) + z_1 O_t Q_t + \varepsilon_t \quad (3.19)$$

3.4.3 Empirical Results

In this part, we employ the MRR model to extract adverse selection component from spreads.⁴⁹ Estimation is carried out with GMM.

3.4.3.1 Estimation procedure

The MRR regression equation is,

$$\Delta P_t = (\theta + \phi) Q_t - (\phi + \rho \theta) Q_{t-1} + \varepsilon_t$$

The three parameters (θ, ϕ, ρ) determine the behaviour of transaction prices. The GMM procedure imposes that the expectation of the following four population moments is zero:

$$E[f(\Delta P_t, Q_t, Q_{t-1}, \theta, \phi, \rho)] = 0$$

⁴⁹ The Glosten-Harris model and Huang-Stoll model simply fail in most of our regressions. In the estimations of Glosten-Harris model, the term capturing the relation between trade sizes and informativeness of trades is rarely significant. In those of Huang-Stoll model, the term capturing inventory-adjustment effects is rarely significant.

$$\text{where } f(\Delta P_t, Q_t, Q_{t-1}, \theta, \phi, \rho) = \begin{pmatrix} Q_t Q_{t-1} - \rho Q_t^2 \\ \varepsilon_t - \varepsilon_0 \\ (\varepsilon_t - \varepsilon_0) Q_t \\ (\varepsilon_t - \varepsilon_0) Q_{t-1} \end{pmatrix}$$

Given (θ, ϕ, ρ) , ε_t is defined as $\Delta P_t - (\theta + \phi)Q_t - (\phi + \rho\theta)Q_{t-1}$. ε_0 is a constant drift term. The second equation defines this constant term as the average price error. The first equation is the definition of the first order autocorrelation of Q_t .⁵⁰ The last two equations are the orthogonal conditions.

3.4.3.2 Estimation results

To endow estimation significance, we include stocks which have at least 30 trades in both pre and post offer periods. Our reduced sample consists of 73 open offers and 27 rights offers. Data filter in Section 3.2.3.1 applies.

Separate estimation is conducted on each event period for each of these stocks. According to the type of a stock (open offers/rights offers) and the event period (pre/post), we calculate the mean estimated coefficients, the mean standard error, the standard deviations of the estimates, and the median of the estimates for adverse selection component θ and the temporary component ϕ . With the coefficients estimated, we also calculate the implied spread $2(\theta + \phi)$, the proportion of the adverse selection component in the implied spread $\frac{\theta}{\theta + \phi}$, the proportion of each cost component in trade price, and the implied spread as a percentage of trade price. Summary statistics is provided for these implied measures. The result is summarized in table 7.

Firstly, the estimation results are disappointed, especially the estimation of adverse selection components. 92% of the coefficients for θ is insignificant for the pre-issue open-offer sample; all of those are insignificant for the post-issue open-offer sample. There are even some estimates (about 30%) are negative, although the negative ones are all insignificant. Similar things happen in the estimation for the rights-offer sample.

Although the estimation result is highly unreliable, we continue to interpret to see whether they make any economic sense. For the open-offer stocks, the mean value of adverse selection component θ is £0.005 and 0.24% of trade price for the pre-issue sample, and £0.013 and 0.28% of trade price for the post-issue sample. The mean value of

⁵⁰ Recall that ρ is the probability of trade continuation in the MRR model.

temporary component ϕ is £0.028 and 2% of trade price pre-offer, and £0.027 and 2.3% for post-offer. The mean implied spread is £0.065 and 5% of trade price for the pre-offer period, and £0.082 and 5.2% for the post-offer period. Adverse selection component contributes 5% of spread pre-offer and 2.5% post-offer.

For the rights-offer stocks, the mean value of adverse selection component θ is £0.017 and 0.04% of trade price for the pre-issue sample, and £0.009 and 0.1% for the post-issue sample. The mean value of temporary component ϕ is £0.06 and 1.4% of trade price pre-offer, and £0.05 and 1.5% post-offer. The mean implied spread is £0.15 and 3% pre-offer, and £0.11 and 3.2% post-offer. Adverse selection component contributes 2.3% of spread pre-offer and 100% of that post-offer. The last number is incredible. After we check each individual regression, we find that in 3 regressions, the estimators of adverse selection component are so negative that the implied spreads are negative. This push the proportion of θ on spreads above 100%.

The mean standard error and the sample standard deviation confirm the results of individual regression in that the estimators of adverse selection component are no different from 0.

While we feel meaningless to continue with MRR, for the sake of procedure completeness, we test the hypothesis of reduction of asymmetric information by comparing θ between pre offer and post offer for each type of offers. We use group mean tests to test the hypothesis. For each stock i , we get two estimators of adverse selection components: θ_i^{Pre} and θ_i^{Post} . Reduction of asymmetric information can be measured by $\theta_i^{Pre} - \theta_i^{Post}$. Significance of the reduction can be measure by T ratio.

$$t_i = \frac{\theta_i^{Pre} - \theta_i^{Post}}{\sqrt{VAR(\theta_i^{Pre}) + VAR(\theta_i^{Post})}}$$

To test whether the whole sample experiences reduction, we can calculate the t ratio for the mean t_i :

$$T = (\sum_{i=1}^N t_i) \times \sqrt{N}$$

For the open-offer sample, t ratio of the reduction of adverse selection components is -0.13, and t ratio of the reduction of adverse selection components as percentage of spreads is -0.37. Both suggest that there is no resolution of asymmetric information. For the rights-offer sample, t ratio of the reduction of adverse selection components is 0.11,

and t ratio of the reduction of adverse selection components as percentage of spread is -0.08. Again, no resolution of asymmetric information. Of course, we should not rely on this result since the methodology itself is not reliable.⁵¹

In what follows, we try to save the MRR model. The insignificance of adverse selection component may be due to the existence of uninformed trades.⁵² It may be the case that small trades make up a large fraction of transactions and therefore the MRR estimator of θ is diluted toward zero. To save the MRR model, we may get rid of small trades and leave only trades with price impacts in the trade-sequence. We admit that this is not far way from cooking data.

We try this on a restricted sample: only stocks with at least 200 trades (10 trades per day) on each event period are included. The restricted sample contains 25 open-offer stocks and 10 rights-offer stocks. For each of these stocks, we first conduct a price impact analysis⁵³, and try to identify an upper bound of trade size below which trades on average do not have price impacts. After the upper bound is identified, trades with size below it are picked out of the trade sequence. Then we apply MRR to this new trade sequence.

The result is summarized in table 8. It looks slightly better than before: fewer estimators of adverse selection component are insignificant; fewer are negative. For the open-offer stocks, the pre-offer mean value of adverse selection component is £0.01 and 0.26% of trade price; the post-offer mean value of θ is £0.03 and 0.33%. For the rights-offer stocks, the pre-offer mean value of θ is £0.06 and 0.41% of trade price; the post-offer mean value of θ is £0.014 and 0.24%.

However, the proportion of insignificant estimators of θ is still close to 1. The mean standard error and the standard deviation of θ still suggest that adverse selection component is not significant. So we believe that MRR is not a valid methodology, at least for London SEAQ.

For the sake of completeness, we conduct group mean tests of reduction of adverse selection component. T ratios are all insignificant for the open-offer stocks and the rights-offer stocks, which suggest asymmetric information is not resolved with equity offers. But again, this result should be subject to further investigation.

⁵¹ A critique on decomposing spread models will be provided in Section 3.4.4.

⁵² In the next section, we establish that small trades do not have impacts on market makers' beliefs about a stock value.

⁵³ Price impact analysis will be introduced in the next section.

3.4.4 Critique of Decomposing Spread Model

The three decompose-spread models introduced in Section 3.4.2 are all motivated by Glosten and Milgrom (1985). Market makers infer information with order flows and update their beliefs accordingly. The crucial ingredient of a decompose model is market makers' information-revealing strategy. MRR and Huang-Stoll propose that market makers infer information from unexpected order flows, which seems convincing in an automated trading market where trading is anonymous.

However, London SEAQ is a human intermediated market where a small group of participants (market makers, brokers and financial institutions) frequently trade with each other on long-term basis. Can market makers do better than simply focusing on the unexpectedness of trade flows? Recent literature has suggested that there exists information sharing between market participants, not only between market makers (Cao et al.(2000)), but also between market makers and traders (Glosten (1989), Garmill (1990) and Benveniste et al. (1992)). Glosten (1989) and Garmill (1990) suggest that institutional design, e.g. human intermediation, can reduce the burden of asymmetric information. Garmill demonstrates that market makers can heighten competition among informed traders by compensating only the first one to reveal private information. Benveniste et al. (1992) argues that market makers can mitigate the effects of asymmetric information by improving price for those traders with good reputation of not harming market makers with private information. No matter the "carrot version" or the "stick version" of price improvement, it suggests that the adverse selection market makers face is no longer a pure probabilistic problem. So is it rational to propose market makers' information revealing strategy as purely updating according to unexpected order flows? We strongly feel that this is not correct, especially for London SEAQ which is famous for its high degree of human intermediation.

Although they are not appropriate for human intermediate markets, are they sensible for automated trading markets? In a market of this type, participants can observe trade size and trade time. As in Easley and O'hara (1987) on trade size and Admit et al. (1988) on trade time, these two choices of traders can reveal information to the market. We don't think that unexpectedness of trade flows itself can summarize all these information.

Huang-Stoll also proposes market makers' inventory reversal strategy. They believe that mid-point can be an instrument for market makers to induce inventory equilibrate trades. In London SEAQ and other dealership markets like NASDAQ, there exists a

separate market (IDB for LSE, ECM for NASDAQ) where market makers can trade with each other to off-load unnecessary inventory. That is, when trades result in their holding non-optimal inventory, they have at least two choices to reverse their holdings back to optimal: they can adjust mid-point to induce trades in the direction they want, or they can trade directly with other market makers with opposite holdings. With data for London stock exchange, Reiss and Werner (1998) documents that inter-dealer trades take place when dealers are experiencing extreme inventory position. They argue that inter-dealer trades facilitate risk sharing among dealers. Besides, in our next section, we will show that after a transaction, mid-point continues to drift in the direction of the trade, which is inconsistent with mid-point as an instrument to reverse inventory. All these are against Huang-stoll's hypothetical inventory strategy. As a matter of fact, estimated coefficients for Q_{t-2} in Huang-stoll model most of the time are insignificant. Since Q_{t-2} is the term to capture movement of mid-point motivated by inventory consideration, its insignificance supports our notion that market makers choose to trade with other market makers through IDB to off-load inventory.

Glosten and Harris (1988) propose a linear relation between adverse selection effect and trade size. In all dealership markets, market makers quote not only prices, but also sizes. Prices are tradable given that order size is below the quote size. Orders with size above quote size will be subject to bilateral negotiation between traders and market makers. Human intermediation is unavoidable for these trades. Recent literature (e.g. Barclay and Warner (1993)) documents that it is median trades that move prices. The logic is that informed traders do not want to expose their identity, and thus break up their block orders into median ones and spread the trades over time. All these suggest median size trades may be the main source of adverse selection. If so, the relation between adverse selection and trade size will not be linear. Glosten-Harris's model fails to allow for this possibility.

3.5 Price Impact Analysis

Price impact method is another way to identify the degree of adverse selection. In this section, we employ it to test the hypothesis of resolution of asymmetric information with equity offers. A trade has two types of impacts on price: temporary impact and permanent impact. The permanent impact of a trade can be used to measure the amount of private information impounded by this trade, and can be a measure of the degree of adverse

selection. If equity offers resolve asymmetric information, the permanent impact of a trade should be smaller post equity offers.

It has been argued that adverse selection has a systematic pattern related to trade size (Easley and O'hara (1987)). In our analysis, we will group trades into 3 size categories, small, median, or large. Small trades are defined as the smallest 20% purchases and smallest 20% sales below quote size. Median trades are defined as the biggest 20% purchases and biggest 20% sales below quote size. Large trades are defined as trades with size above quote size.⁵⁴ We then identify the size categories of which trades have significant permanent impacts. For these size categories, we compare the permanent impacts of trades between the pre-offer period and the post-offer period. If the permanent impacts fall significantly after equity offers, it suggests resolution of asymmetric information during equity offers.

Beside the main hypothesis, we also investigate the pattern of adverse selection in London SEAQ and firms' choices of flotation methods. Adverse selection may be related to trade size (Easley and O'hara (1987)). Block purchases and block sales may not be symmetrically informative (e.g. Keim and Madhavan (1996)). Human intermediation, which is an important feature of London SEAQ, may effectively separate informed trades with liquidity trades and thus may affect the pattern of adverse selection (Lawrence, et al. (1992)). When the degree of asymmetric information is high, it may be more likely for a firm to conduct equity private placements (Hertzel and Smith (1993) and Cronqvist and Nilsson (2005)). We will investigate these issues with the measure of adverse selection obtained with price impact method.

3.5.1 Methodology

The methodology employed in this section follows that in Holthausen, Leftwich and Mayers (1987, 1990). Trade flows have impacts on price: temporary impact and permanent impact. Temporary impact is the price concession which compensates liquidity providers. Permanent impact comes from the information impounded by trade flows. It drives market makers to revise their beliefs about security value. The size of permanent impact is positively related to the degree of adverse selection. If choices of equity offer methods resolve asymmetric information, permanent impact of trades should be smaller in the post-offer period than in the pre-offer period.

⁵⁴ The motivation and the detail of our grouping method will be introduced in the next section.

The permanent impact of a trade can be measured by the market makers' belief revision about the security value during that trade. Since market makers' beliefs on average can be measured by mid point, mid-point returns can be used as a measure of the revision. To control for any systematic return patterns, e.g. SEOs price effects, we need a bench-mark return which is considered to be the return when there is no permanent impacts from trades. A commonly employed bench-mark return for a trade is the average mid-point returns of a sequence of trades before that trade. The excess return of that trade over its bench-mark return is considered to be the permanent impact of that trade.

Market makers' beliefs may not be adjusted immediately after a trade. Post trade transparency in LSE is low in that the exchange allows for the late publication of trades with size above 3 NMS. The trading counterparties of such a trade have information advantage over other market participants. The relevant market maker can use this advantage to update his belief or even make profits on it. However, other market makers will for a period lack of necessary information to make update. Therefore, the overall belief updating process of market makers may be gradual. On the other hand, since trades can be human intermediated, these trades will be subject to negotiations before they are executed. This creates the possibility of information leakage. Burdett and O'Hara (1987), and Keim and Madhavan (1996) document pre-block-trade price movements in NYSE which is consistent with information leakage hypothesis. The above definition of permanent impact of a trade may thus underestimate the true belief revision since market makers may start to adjust well before that trade because of information leakage, or not until late after it because of late publication.

To allow for these possible belief-revision behaviours, we not only calculate the return of that specific trade, but also the mid-point returns of a series of trades before and after it. Following convention, we focus on the return sequence from the 5th trade before that trade to the 5th trade after it. The benchmark return is the average mid-point return of the trade sequence from the 20th to the 10th trade before that trade. Label the specific trade as the 0th trade. Mid point returns of the -4th, -3rd, -2nd, -1st trade, and those of the 2nd, 3rd, 4th, 5th trades are calculated; mid point to trade price return of the 0th trade, and trade price to mid point return of the 1st trade are calculated. The bench-mark return is subtracted from these returns, and it yields the excess returns.

Previous literature (e.g. Holthausen, Leftwich and Mayers(1990), and Gemmill (1996)) employ trade price to trade price returns to measure excess returns. We claim that using

trade prices are obscured by the noise associated with bid-ask bounces.⁵⁵ Instead, we employ mid point returns to measure excess returns. Firstly, microstructure literature generally contends that market makers' beliefs of a stock's value on average can be measured by mid point, e.g. Glosten and Milgrom (1985). Secondly, mid point returns are not subject to the noise from bid-ask bounces and therefore illustrate the impacts from trades better. Essentially, our method shares the same spirit with that in Koski and Michaely (2000) who use ask price returns or bid price returns to measure excess returns.

We use mid-point-to-trade-price return for 0^{th} trade and trade-price-to-mid-point return for 1^{st} trade in order to assess total price impacts from trades. Total price impact of a trade is the sum of the trade's temporary impact and permanent impact. We can measure it with the cumulative abnormal return at the 0^{th} trade. Using mid prices and trade prices at the same time is not as unorthodox as it sounds. In Holthausen, Leftwich and Mayers (1987) and Keim and Madhavan (1996), they used the trade price of a block trade and the market closing prices 1-day before and 1-day after the block trade to measure the block trade's price impact in NYSE.⁵⁶ The mid prices in our analysis resemble the closing prices in their work. However, we claim that their method is not appropriate for our analysis. During the time between a specific trade and market closing, other trades with information content, e.g. median trades, may take place fairly frequently. These trades may move prices. If we use the market closing prices and the trade price of that specific trade to measure the price impact of that specific trade, the measure will likely be contaminated by the impacts from other informed trades.

The previous works mainly focus on the price impacts of block trades. In our work, block trades may not be enough to address the pattern of adverse selection since it is very likely that trades other than block trades can contain information. According to Barclay and Warner (1993), median trades are even more informative than large trades since traders, in order to conceal their identity, break up their large informed orders into median ones so as to avoid human intermediation.

We group trades in London SEAQ into three size categories: small trade, median trades and large trades. Small trades are defined as the smallest 20% purchases and smallest 20% sales below quote size. Median trades are defined as the biggest 20% purchases and

⁵⁵ For example, the excess return measure in Gemmill (1996) is fairly volatile. Statistical inferences are essentially not easy to draw in his paper.

⁵⁶ In NYSE, the price formation mechanism during the day is different from that at market closing. During the day, prices are formed with a hybrid mechanism between continuous auction and dealership. At market closing, a batch auction takes places to clear the market.

biggest 20% sales below quote size. Large trades are defined as trades with size above quote size.

Previous literature use dollar volume to define the size of a trade. We do not think that this method is appropriate for us since we do not have prior knowledge of the relation between adverse selection and pound volume in LSE, and even if we have, this relation is likely to be varied across stocks. We believe that a better method should utilize quote size.

Quote size summarize market makers' information of the trading and informational characteristics of a stock. In SEAQ, orders above quote size have to be subject to negotiation between the relevant market maker and the trader who initiates it. This segment of the market is similar with the up-stair market in NYSE.⁵⁷ One can understand our large trades as the block trades in NYSE. When the sizes of their orders are below quote size, traders can ensure the transaction by electronically taking the quotes made by market makers. Or they can employ brokers to negotiate with market makers for price improvement. Under Barclay and Warner's logic, traders who break up their large informed orders should have the sizes of their broken orders close but below quote size, and should submit them electronically. Thus the median trades in Barclay and Warner (1993) should be corresponding to the median trades in our analysis. One might argue that why we do not use NMS to define trade size category, as in Naik et al. (1998). We believe that quote size contains more information than NMS. The reason is that the exchange regulations require quote size to be at least one NMS. If the chosen quote size is different from one NMS, the difference must reflect market makers' knowledge about the degree of adverse selection since quote size is an effective instrument for them to guard against adverse selection.

We will investigate the permanent impacts of the three types of trades. We expect their impacts are different. Our main object is to pick up those types of trades which are informative, and check whether their permanent impacts change after equity offers. If the permanent impact of informative types of trades drops after both open offers and rights offers, then choices of equity-flotation-methods resolve asymmetric information.

The detail of the excess-return calculations is introduced in what follows. Take large purchases as an example. We first spot all the large purchases of a stock. Denote the number of large purchases as N^{LB} . Label the large purchases with $i=1, 2, \dots, N^{LB}$. For

⁵⁷ A big difference is that market makers most of the time trade as principle, but up-stair brokers work as marketing agents to facilitate the trades

each purchase i , we construct two trade sequences for it: a trade sequences from -5^{th} to 5^{th} , and a bench mark sequence from -20^{th} to -10^{th} .

The t^{th} trade return R_{it} is calculated as,

$$R_{it} = \text{Log}\left(\frac{M_{i,t}}{M_{i,t-1}}\right)$$

For $t=-19, -18 \dots -10$, and $-4, \dots -1$, and $1 \dots, 5$.

$M_{i,t}$ is the mid point of the t^{th} trade. For $t=0$, the return is calculated as,

$$R_{i,0} = \text{Log}\left(\frac{P_{i,0}}{M_{i,-1}}\right)$$

$P_{i,0}$ is the transaction price of the i purchase. For $t=1$, the return is calculated as:

$$R_{i,1} = \text{Log}\left(\frac{M_{i,1}}{P_{i,0}}\right).$$

The excess return for t^{th} trade, $t = -4, -3 \dots 0, \dots 5$, are averaged across all the i ,

$$\overline{RX}_t^{LB} = \frac{\sum_{i=1}^{N^{LB}} R_{i,t} - BEN^{LB}}{N^{LB}} \quad (3.20)$$

$$\text{Where } BEN^{LB} = \frac{\sum_{i=1}^{N^{LB}} \sum_{t=-19}^{-10} R_{i,t}}{10 \times N^{LB}}$$

The cumulative excess return for the t^{th} trade, $t = -4, -3 \dots 0, \dots 5$, is calculated as:

$$\overline{CRX}_t = \sum_{j=-4}^t \overline{RX}_j^{LB} \quad (3.21)$$

The total price impact of large purchases can be measured by \overline{CRX}_0 . The permanent impact of large purchases can be measured by \overline{CRX}_t with $t = 1, 2 \dots 5$. Which t to choose depends on how fast information is incorporated into prices.

3.5.2 Data

Price impact analysis requires enough a long trade sequence in an event period. From our original sample, we select stocks with at least 200 trades (10 trades per day) in each event period into our price-impact-analysis sample. Our new sample contains 25 open offer stocks and 10 rights offer stocks.

For each stock, we obtain extra data of market makers' quotes. The data contains information about the NMS, every quote submitted, quote time, quote size and identity of

the market maker who submits a specific quote. From these, we can generate information for each stock about the number of its market makers, how many trading days each of the market makers is active, and the maximum and minimum of quote size. We can also calculate the average number of market makers per day in each event period. All these are summarized in table 9.

Quote size is restricted to be above one NMS unless a market maker obtains special permission from the exchange (Naik et al. (1998)). In most of the stocks (20 of the 25 open offers stocks, and all the rights offer stocks), market makers' quote sizes are between one NMS and three NMS. Market makers for a stock do not necessarily quote the same size. This may reflect differential capacities of the market makers and different beliefs about the information characteristics of the stock. Each of them sticks on a specific size and changes it at most once in the event period.

The choice of quote size with which we define trade size category is not unique when market makers do not quote the same size. We prefer to use the maximum quote size because informed traders are free to trade up to this quote without exposing his identity. We content that a quote with maximum size may not always be the best quote and thus informed traders have a trade-off between taking the best quote and taking the largest size. Our point is that we want all our large trades to be human intermediated.

For all the open-offer and all the rights-offer stocks, the average number of market makers per-day in the post-offer period is at least the same with that in the pre-offer period. This suggests that there is entry of market making. New market makers may join the business either during the pre-offer period⁵⁸ (3 cases for the open-offer stocks and 2 cases for the rights-offer stocks) or during the post-offer period (6 cases for the open-offer stocks and 2 cases for the rights-offer stocks).

There is no systematic change of quote size during equity offers. For the open-offer stocks, average quote size stays the same in 15 stocks. For the other 10 stocks, 5 increase and 5 decrease. For the rights-offer stocks, average quote size stays the same in 5 stocks. For the other 5 stocks, 3 increase and 2 decrease.

With the detail of quoting behaviour, we can set up a more delicate trade-data filter in addition to the data filter in Section 3.2.3.1. Each stock has two trade sequences, pre and post. In each sequence, we first specify the trades that fall into any of the three trade-size

⁵⁸ One can identify it by comparing the average number of market makers per-day with the number of market makers in Table 9, Panel A and B. If the later is larger, one can infer that new market maker joins the business in that event period.

category. In the following cases, a trade will be excluded from our three size groups even though its size is within any of the three size ranges.

1. Trades with size below the minimum quote size and price outside the best bid ask are excluded. Order preferencing breaks the trading rule of price and time priority. That is, an order may not be forwarded to the market maker who is the first one that quotes the current best prices. But the exchange requires the relevant market maker to offer best execution. He must at least match the best price available to the order. A trade with size below minimum quote size should obtain a price as least as good as the best bid or ask. The existence of such abnormal trades may be because the recorded errors of either quote time or trade time. In this case, the mid point of the trade can not reflect market makers' belief of stock value.
2. The first and the last trade of a day are excluded. Since before the first trade of a day or after the last trade of a day, there is a long non trading period. Market makers' beliefs may be revised due to overnight information flow (Lockwood and Linn (1990)). That is, the belief revision may not be solely due to the information content of the trade.
3. Agent trades are excluded. Most of the time, market makers in LSE accommodate orders with their own capacities. But they can also act as a marketing agent to match buy and sell. In this case, trade impact is not directly toward market makers. Although we lost information about a trade's identity as principle or agent trade, we find that transaction prices of agent trades are odd in that purchases by customers are executed below mid point and sales are executed above mid point. We exclude trades with such odd characteristics.

We rule out the above three types of trades to be our 0^{th} trades, but we do not get rid of them from the trade sequence. When these trades act as time t ($t \neq 0$) trades, we set their mid point return as zero.

Table 10 summarizes the trade sample. For the pre-offer open-offer stocks, we identify 6398 small purchases. The average trade size is 4% of quote size. 4038 small sales, on average 6% of quote size; 5599 median size purchases, on average 60% of quote size; 4303 median sales, 65% of quote size; 2437 large purchases, 370% of quote size; 2359 large sales, 385% of quote size.

For the post-offer open-offer stocks, 4077 small purchases are identified. Their sizes on average are 5% of quote size; 3269 small sales, 6% of quote size; 3669 median purchases,

59% of quote size; 3429 median sales, 64% of quote size; 1899 large purchases, 473% of quote size; 2128 large sales, 522% of quote size.

For the pre-offer rights-offer stocks, 1073 small purchases are identified. They on average have sizes of 4% of quote size; 626 small sales, 5% of quote size; 983 median purchases, 63% of quote size; 578 median sales, 69% of quote size; 572 large purchases, 410% of quote size; 562 large sales, 615% of quote size.

For the post-offer rights-offer stocks, 1065 small purchases are identified. Their sizes are on average 3% of quote size; 509 small sales, 4% of quote size; 950 median purchases, 47% of quote size; 460 median sales, 61% of quote size; 476 large purchases, 522% of quote size; 323 large sales, 505% of quote size.

Trade sizes in the three categories are similar across the above four samples. Small trades are about 5% of quote size. Median trades are about 60% of quote size and 12 times larger than small trades. Large trades are about 500% of quote size and 8 times larger than median trades.

3.5.3 Empirical results

With the methodology described above, we calculate the excess return of trade series from -4^{th} to 5^{th} for each trade in our sample. The excess returns are then accumulated to yield the accumulative excess returns. According to trades' identities (rights offer/open offer, pre-offer/post offer, small/median/large), we group them into 24 sub-groups. Cumulative excess returns are taken average within a sub-group, and T-stats for the significance of the average cumulative excess returns are calculated. The result is presented in table 11.

First, in any sub-group, there is a surge of cumulative excess return from trade -1 to trade 0 . This is because the return from trade -1 to trade 0 is calculated as mid-point to trade price return. The surge comes from the existence of effective half spread, and is not solely due to revision of beliefs (note that effective half spread consists of both temporary impact and permanent impact of a trade). Cumulative excess returns drop radically from trade 0 to trade 1 . The return between them is calculated as trade price to mid point return. This radical drop is due to the vanishing of temporary impact of trade 0 . If market makers update their beliefs immediately, permanent impact of trade 0 can be evaluated with the cumulative excess return at trade 1 . If their revision of beliefs is not immediately due to

lack of information about trade 0, e.g. non-transparency of the market, permanent impact of trade 0 should be evaluated with the cumulative excess return at subsequent trades.

In any sub-group of small trades, the permanent impact is small in scale compared with median and large trades. Through trade 1 to trade 5, the absolute value of the cumulative abnormal return ranges from 0.001% to 0.09%, on average about 0.02%. None of them is significant or significant in right direction (for small purchases of the pre-offer open-offer stocks, the cumulative abnormal return is significant in wrong direction. As Gemmill (1996), we interpret them as uninformed trades). Since small trades in all sub-groups have small and insignificant permanent impacts, we conclude that small trades are uninformed trades for both the open-offer stocks and the rights-offer stocks, and for both the pre-offer and the post offer period.

In any sub-group of median trades, purchases have positive cumulative abnormal returns evaluated at any trades subsequent to trade 0; sales have negative cumulative abnormal returns. All the cumulative abnormal returns subsequent to trade 0 are significant. The scales of the cumulative abnormal returns are much larger than those of small trades, about 0.25%. This implies that median trades have permanent impacts on market makers' beliefs. That is, median trades contain information. The absolute values of cumulative abnormal returns continue to drift up through trade 1 to trade 5. Individual excess returns of trade 1 to trade 5 are almost all significant, which implies that market makers' revisions of belief are not immediate and they continue to revise their beliefs after a median trade.

The cumulative abnormal returns of large trades have similar pattern with those of median trades. Purchases have positive cumulative abnormal returns; sales have negative cumulative abnormal returns. All the cumulative abnormal returns subsequent to trade 0 are significant. Large trades have permanent impact on market makers' beliefs, which implies that large trades also contain information. And the scale of the permanent impact is even larger than that of median trades, evaluated at any trade subsequent to trade 0. But the difference is much smaller than the difference between median trades and small trades. The absolute values of the cumulative abnormal returns continue to drift up after a large trade, which implies that market makers' belief revision is not immediate.

3.5.3.1 Information content and trade size

Easley and O'hara (1987) claimed that information content of a trade may be related to its trade size. To maximize profit, informed traders will make large orders when market

price is different from the true asset value. However, if liquidity traders only make small orders, informed traders will have to mimic the liquidity traders and submit small orders because adverse selection is so severe that the market for large trades can not exist. But if there is enough large size liquidity trading, Easley and O'hara (1987) show that there exists a semi-separating equilibrium where informed traders only trade large size orders.

In Easley and O'hara's semi-separating equilibrium, small trades are not informative, while large trades are. Our work provides evidence for their theory. Small trades, both purchases and sales, both of the open offer stocks and of the rights offer stocks, and both in pre-offer and post-offer period, have no permanent impacts on price, while median and large trades have significant permanent price impacts in all categories. This suggests that a trade's information content does relate to its size. And it also implies that in London SEAQ, there is enough liquidity trading of median and large size so that the median and the large size market can be sustained.

The next question is whether a trade's information content increases universally with its size? By comparing the information content of median-size and large-size trades, we find that the answer is not straight-forwards. Large purchases have significantly larger permanent impacts on price than median purchases, both of open-offer stocks and of rights-offer stocks, and both in pre-offer and in post-offer period. On the other hand, large sales are not more informative than median sales. Especially, for the sales of the rights-offer stocks in pre-offer period, large sales' permanent impacts are even smaller than those of median sales, although the difference is not significant.

Previous theoretical and empirical works have considered the issue of informed traders' choice between median trades and large trades. When an informed trader attempts to achieve a large total share position, he can either make a block trade, or break up the large order into median ones and spread the trades over time. One of the motivations for breaking up a large order is his concern of the price impact of the large order. In NYSE and London SEAQ, a trade who attempts a large trade has incentive to conceal his identity so as to reduce the information-related price impact. If he can not be certified as a liquidity trader, he has to pay a large price concession to liquidity providers. An informed trader faces the possibility of being identified as informed if he submits a large order. It may be in his interest to make several median trades that spread over time. This argument is consistent with Kyle (1985). In Kyle's setup, an informed trader's optimal strategy is to make a sequence of informed trades until price fully incorporates all his private information. Barclay and Warner (1993), with NYSE data, provide evidence that

informed traders will concentrate their trades in median size⁵⁹. The cost of breaking up a large order can be the adverse price movement due to information leakages or some fixed cost of trading, e.g. brokerage commissions.

On the other hand, Gammill (1989) provides a reason for why informed traders may make a large block trade. He presents a “carrot” version of human intermediation, which suggests that market makers will use price improvement to encourage informed traders to share information with them.

Our empirical results on the comparison of median trades and large trades suggest that when an informed trader attempts a large purchase, he is more likely to submit a block order than when he attempts a large sale. Based on Kyle (1985) and Gammill (1989), this implies that market makers are less harsh to traders with positive private information. For this reason, informed buyers have less incentive to break up their large purchase orders.

3.5.3.2 Asymmetric between purchases and sales

Previous research has documented that market response differently to block purchase and block sales. Gemmill (1996) with LSE data, and Keim and Madhavan (1996) with NYSE data find that block purchases have larger permanent impact than block sales.

We document a similar pattern in our large-size trades. For both types of stocks, the absolute values of the cumulative abnormal returns of large purchases are universally higher than those of large sales, evaluated at any trade subsequent to trade t (Table 11-A, B, C, D). The difference is significant or marginally significant⁶⁰ for the open-offer stocks and the pre-offer rights-offer stocks. This suggests that large purchases tend to have more information content than large sales. In Gemmill (1996), large sales do not contain information and the asymmetric between purchases and sales is more significant. The difference between the two results may be due to the definition of large trades. In his work, a trade is considered to be a large (block) trade if its size exceeds 3 times normal market size which triggers the delay of publication. In our work, 3 times normal market size is generally greater than the maximum quote size from market makers. We expect that the size of large trades in Gemmill’s sample is larger than that of ours.

The literature has proposed theory to explain the asymmetric of informative-ness between large purchases and sales. Chan and Lakonishok (1993) argue that for institutional investors, there are many liquidity-motivated reasons to dispose a stock, but

⁵⁹ They define median size as 500 to 9,900 shares.

⁶⁰ One sided test

choosing to buy a specific stock out of numerous alternatives is likely to convey information. Saar (2001) argues that the difference of information contents between buys and sells comes from institutional investors' trading strategies: they buy a stock only when they discover favourable information, but they sell a stock when they find unfavourable information or no special information.

Interestingly, in the median-size category, the asymmetric between purchases and sales goes the other way around. As in table 11-A, B, C, D, median sales tend to have larger absolute permanent impacts than median purchases. The difference is significant or marginally significant for the open-offer stocks and the pre-offer rights-offer stocks. This suggests median sales tend to have more information content than median purchases. Taking into account the asymmetric between large purchases and large sales, we suspect that informed traders handle large purchases and large sales with different strategies: when they attempt a large informed purchase, they tend to directly negotiate with market makers and make a block transaction; when they attempt a large informed sale, they may try to conceal their identities, and break down the order and off-load them bit by bit by taking market makers' quotes. This intuition is subject to further research.

3.5.3.3 Resolution of asymmetric information

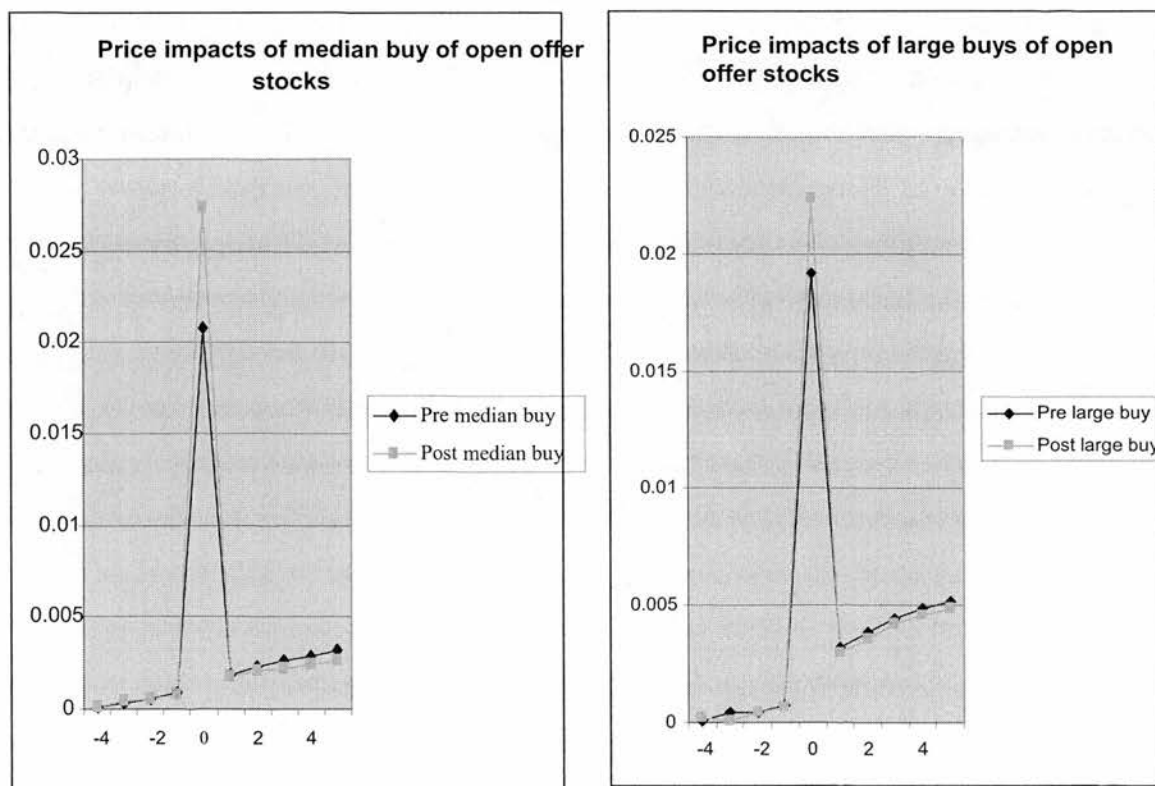
To examine the hypothesis of resolution of asymmetric information, we can compare the pre-offer permanent impacts of informed trades with those in the post-offer period. If asymmetric information is resolved, permanent impacts of informed trades should be smaller in the post-offer period. Since we have established that small trades do not contain information, we can focus on the permanent impacts of median trades and large trades.

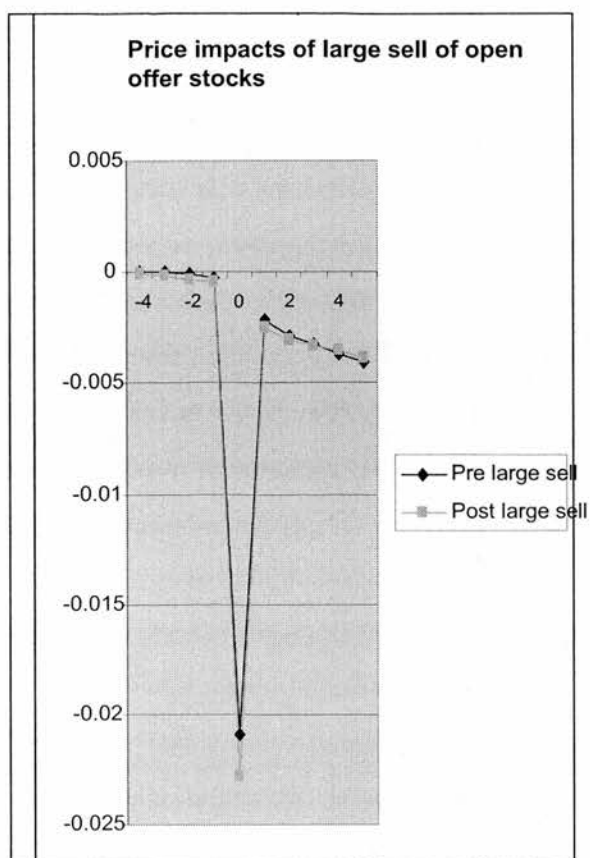
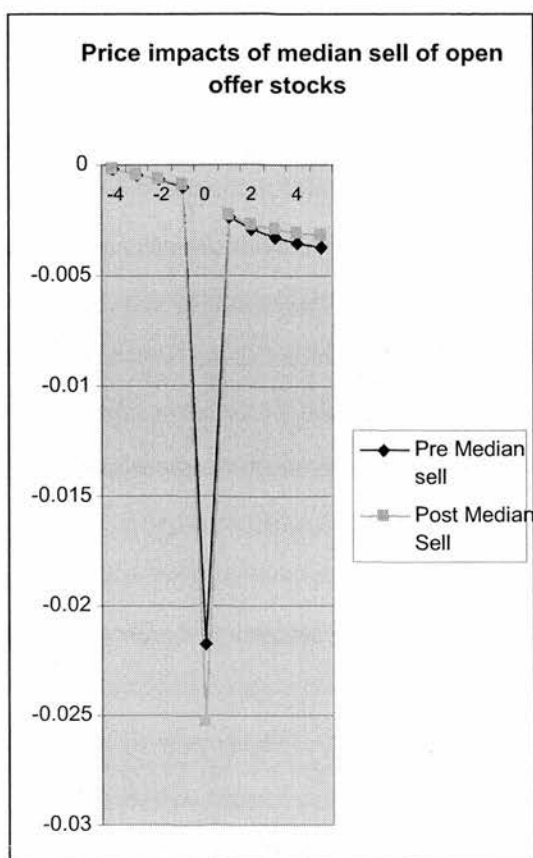
In table 11-A and B, for the open offer stocks, the absolute values of the cumulative abnormal returns of the median trades, both purchases and sales, in the post-offer period are smaller than those in the pre-offer period, evaluated at any trade subsequent to trade 0. The cumulative abnormal returns of the large purchases in the post-offer period are also uniformly smaller than those in the pre-offer period. For the large sales, the result is a bit ambiguous. The absolute values of CAR in the post-offer period are greater than those in the pre-offer period at trade 1, 2 and 3, but they become smaller at trade 4 and 5. Overall, we get a feeling that price impacts of informed trades in the post-offer period are smaller. That is, for the open-offer stocks, trades are less informative after equity offers. The comparison can be best illustrated by Graph 3.1. The pre-offer CAR is represented by a

black line; the post-offer CAR is by a red line. Subsequent to trade 0 , the black line most of the time dominates the red line.

One thing interesting is that although price impacts of the post-offer informed trades are smaller than those pre-offer, the execution quality of informed trades in the post-offer period is worse. From the graph, the peak of a line represents the effective half spread of trade 0 . The peaks of the red lines are always above those of black lines. Market makers for the open-offer stocks offer less price improvement when the degree of asymmetric information is lower. We think that this is consistent with “carrot” version of human intermediation: the overall “bonus” offered by market makers to informed traders who share information with them is smaller when there is less private information in the market.

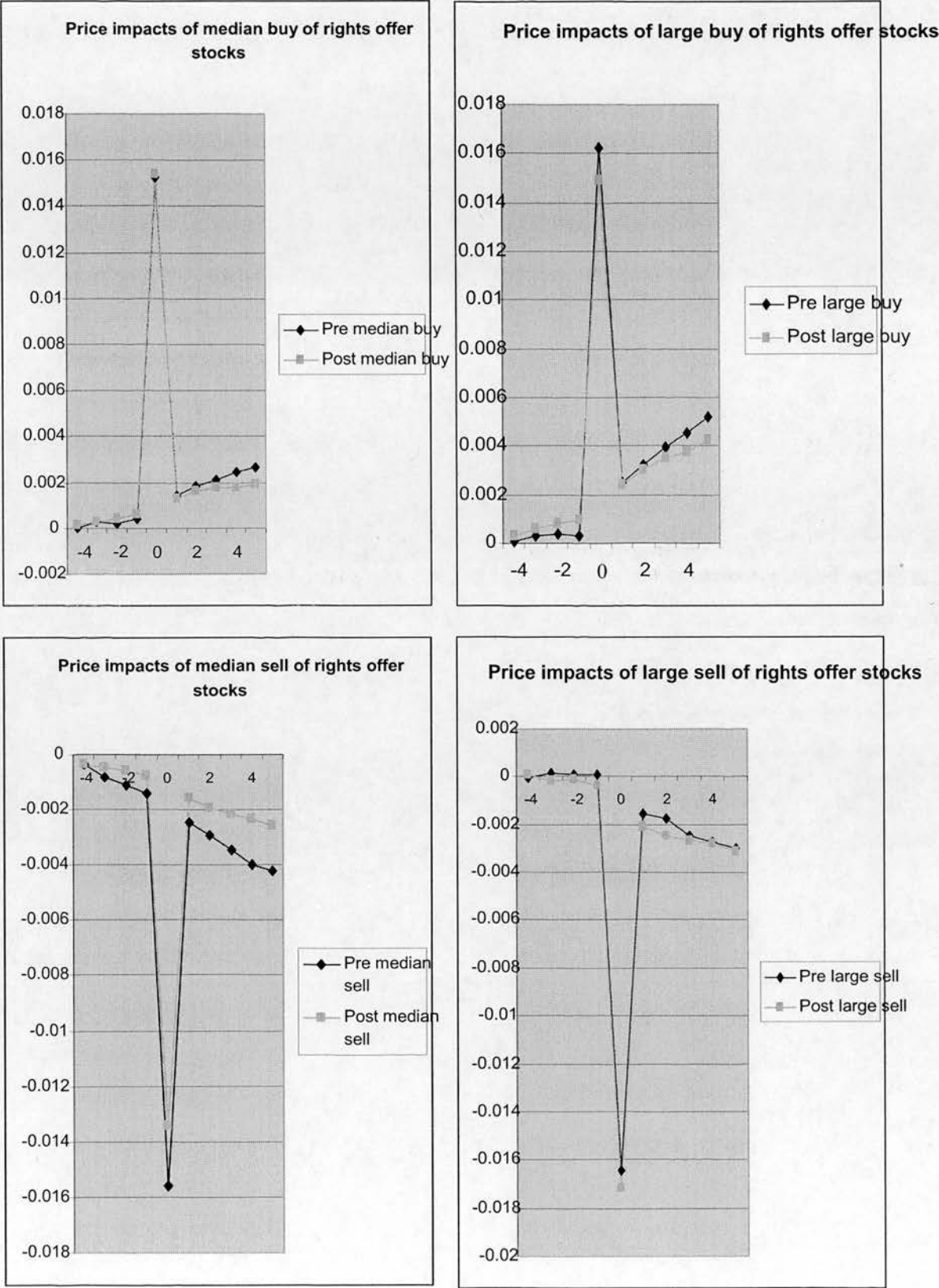
Graph 3.1 Comparison of price impacts between pre offer and post offer for the open-offer stocks.





For the rights-offer stocks, in the post-offer period, the absolute values of CAR of the median and the large purchases, and the median sales are smaller than those in the pre-offer period, evaluated at any trade subsequent to trade 0. From Graph 3.2, we can see that after trade 0, the black line dominates the red line in the graph for the median trades and the large purchases. That is, the permanent impacts of informed trades are lower in the post-offer period in these trade categories. Again for the large sales, the result is different. The permanent impacts of the large sales increase after equity offers. Overall, although there is some evidence of decreases in permanent impacts of informed trades after equity offers, the result is less clear for the rights-offer stocks.

Graph 3.2 Comparison of price impacts between pre offer and post offer for the rights offer stocks



For the rights offer stocks, execution quality seems to change in the direction of changes in the permanent impacts of trades: the large purchases and the median sales get better execution after equity offers when they become less informative; the large sales get worse execution when they become more informative. This pattern is different from that of the open-offer stocks where execution quality changes in the opposite direction of the change of informative-ness of trades. This seems to suggest a “stick” version of human intermediation for the rights-offer stocks: market makers punish informed traders by requiring more price concessions.

In order to test the hypothesis of resolution of asymmetric information, we construct the following regression model:

$$|CAR_t| = \beta_{0t} + \beta_{1t}D_{OMPr} + \beta_{2t}D_{OMPo} + \beta_{3t}D_{OLPr} + \beta_{4t}D_{OLPo} + \beta_{5t}D_{RMPr} + \beta_{6t}D_{RMPo} + \beta_{7t}D_{RLPr} + \beta_{8t}D_{RLPo} + \varepsilon_t \quad (3.22)$$

Where $|CAR_t|$ is the absolute value of the cumulative abnormal return evaluated from $-t^{th}$ trade to t^{th} trade, $t \in [1, 5]$.

D_{OMPr} : Dummy for median trades of pre-offer open-offer stocks.

D_{OMPo} : Dummy for median trades of post-offer open-offer stocks.

D_{OLPr} : Dummy for large trades of pre-offer open-offer stocks.

D_{OLPo} : Dummy for large trades of post-offer open-offer stocks.

D_{RMPr} : Dummy for median trades of pre-offer rights-offer stocks.

D_{RMPo} : Dummy for median trades of post-offer rights-offer stocks.

D_{RLPr} : Dummy for large trades of pre-offer rights-offer stocks.

D_{RLPo} : Dummy for large trades of post offer-rights-offer stocks.

We will run 5 regressions as t may take value from 1 to 5. Regressions are conducted with White, H. (1980) Heteroscedasticity-consistent covariance matrix estimate. β_{0t} captures the price impact of small trades. From the previous analysis, small trades do not have significant permanent price impact. We expect that the constant term will be insignificant. Coefficient of a dummy variable captures the cumulative excess return of the type of trades the dummy represents. Resolution of asymmetric information can be tested by:

$$H_0 : \beta_{1t} = \beta_{2t} \text{ and } \beta_{3t} = \beta_{4t} \text{ and } \beta_{5t} = \beta_{6t} \text{ and } \beta_{7t} = \beta_{8t} \text{ (no resolution)}$$

$H_1 : ((\beta_{1t} > \beta_{2t}) \text{ or } (\beta_{3t} > \beta_{4t})) \text{ and } ((\beta_{5t} > \beta_{6t}) \text{ or } (\beta_{7t} > \beta_{8t}))$ (resolution of asymmetric information)

Table 12. Regression results.

Excess Return Window	Open offer/Right issue	Median/Large trades	Pre issue permanent impact	Post issue permanent impact	Significance of the reduction of Price impact during equity offers
			T Statistics below	T Statistics below	T Statistics (one sided P value below)
(From - 5 trade to +5 trade)	Open	Median	0.3549% 13.52	0.3014% 10.85	1.5663857 0.05863
		Large	0.4772% 12.72	0.4468% 10.92	0.57481807 0.28271
	Right	Median	0.3374% 5.709	0.2272% 4.675	1.4780882 0.069695
		Large	4.22E-03 5.069	3.93E-03 5.709	0.27075578 0.39329
Small trades		Price Impact	-0.0133%	T-ratio	-1.1
(-4, +4)	Open	Median	0.3142% 14.17	0.2709% 11.45	1.4863135 0.0686
		Large	0.4391% 13.66	0.3999% 11.58	0.87070078 0.19196
	Right	Median	0.3017% 5.922	0.1888% 4.67	1.7793566 0.037595
		Large	0.3727% 5.256	0.3319% 5.601	0.44713282 0.32739
Small trades		Price Impact	-0.0111%	T-ratio	-1.109
(-3, +3)	Open	Median	0.2631% 14.62	0.2214% 11.56	1.7554061 0.0396
		Large	0.3755% 14.13	0.3684% 13.1	0.19101879 0.424255
	Right	Median	0.2234% 5.465	0.1679% 5.231	1.10 0.1367
		Large	0.3278% 5.699	0.2840% 5.757	0.5852061 0.279205
Small trades		Price Impact	-0.0102%	T-ratio	-1.274
(-2, +2)	Open	Median	0.2057% 14.84	0.1814% 12.59	1.3320372 0.091425

		Large	0.3167%	0.3030%	0.48246059
			15.49	14.32	0.31474
	Right	Median	0.1777%	0.1313%	1.2500296
			5.963	5.562	0.105645
		Large	0.2413%	0.2322%	0.16219971
			5.582	6.405	0.435575
Small trades		Price Impact	-0.0061%	T-ratio	-1.059
(-1, +1)	Open	Median	0.1228%	0.1207%	0.18262414
			14.54	12.99	0.427545
	Large		0.2251%	0.2224%	0.13709084
			15.61	15.32	0.44548
	Right	Median	0.1079%	0.0809%	1.1736687
			6.01	5.316	0.120265
		Large	0.1962%	0.1596%	0.99531924
			6.839	6.8	0.159795
Small trades		Price Impact	-0.0048%	T-ratio	-1.379

The results are presented in Table 12. First as we expected, constant terms are never significant. Small trades do not have permanent impacts. Secondly, the coefficients for the 8 dummy variables are uniformly significant in all regressions. This indicates that median trades and large trades have permanent price impacts and are informative.

The coefficients for the post-offer dummies are uniformly smaller than the corresponding pre-offer dummies in all regressions. That is, $\beta_{1t} > \beta_{2t}, \beta_{3t} > \beta_{4t}, \beta_{5t} > \beta_{6t}, \beta_{7t} > \beta_{8t}$ for $t \in [1, 5]$. This gives us some feeling of resolution of asymmetric information.

We further conduct tests of the significance of the reduction of permanent impacts after equity offers. We find that $\beta_{3t} > \beta_{4t}, \beta_{7t} > \beta_{8t}$ are not significant in all regressions. That is, the permanent impacts of large trades are not significantly smaller after equity offers for both open-offer and rights-offer stocks.

But for median trades, there is evidence of reduction of permanent impacts. For $t = 4$ and $t = 5$, $\beta_{1t} > \beta_{2t}$ and $\beta_{5t} > \beta_{6t}$ are significant at 90%. Thus we may argue that for both the open-offer and the rights-offer stocks, information content of median trades decreases after equity offers. Given that the information content of large trades insignificantly decreases, we conclude, weakly, that asymmetric information is resolved with equity offers.

Asymmetric information of firms' value gives rise to an adverse selection problem in equity finance market. The market rationally expects the adverse selection problem and responds negatively to equity offers. It has been argued that firms, in response to the inefficiency induced by adverse selection, may signal their unobservable values through choices of equity flotation methods (e.g. Eckbo and Masulis (1992)). In the placing process of UK open offers and private placements, potential placees will investigate the issuers and decide whether to buy (Armitage (2002)). Issuers of different qualities are differentially able to pass the investigations, with high quality issuers being better able to. Thus, high quality issuers may employ private placements or open offers to signal quality. Armitage and Snell (2003) formalize this intuition and establish that there exists a separating equilibrium where only good firms choose open offers to signal quality.

Our empirical findings support the signalling argument in Armitage and Snell (2003). Under their theory, high quality firms signal quality by choosing open offers or private placements. The market can observe a firm's choice of flotation methods and can infer the firm's quality from its choice. Thus, insider information about a firm is revealed to the market with equity offers. The amount of private information about the firm is reduced. As a result, in the secondary market, informed traders' informational advantage over market makers is lessened. The information content of informed traders' orders decreases.

Our findings confirm this theory. We find that the information content of median trades marginally significantly decreases and that of large trades insignificantly decreases. Overall, our findings suggest that asymmetric information is resolved with equity offers. Together with Armitage and Snell (2003)'s finding of positive price effects of UK open offer and negative price effects of rights offers, our result suggests that asymmetric information is resolved with firms' choices of equity flotation methods, and open offers are employed by good firms to signal quality to the market.

3.5.3.4 Comparison of information content of trades between open-offer and rights-offer stocks

Chemmanur and Fulghieri (1999) model the equity selling choice between public offers and private placements. They establish that when a firm's value is more difficult to evaluate, it is more likely for the firm to choose private placement. This theoretical result is confirmed by the empirical findings in Hertznel and Smith (1993) and Cronqvist and Nilsson (2005).

Our firms' choices between rights offers and open offers may also be affected by a similar concern. In an open offer, a firm will communicate its inside information to a small group of placement investors. While in a rights offer, considering the disperse ownership of a public firm, the inside information will have to be transmitted to numerous investors. When the inside information is difficult to evaluate, it is reasonable for a firm to choose open offers so as to save the information-transmission costs. The statistics derived in Section 3.2 seems to support this intuition. In our sample, firms choosing open offers tend to have smaller market values than those choosing rights offer do; trading is less active, both in terms of pound volumes and share volumes. This suggests our open-offer firms are small and new firms, and are followed by fewer analysts. And therefore, their values may be difficult to evaluate.

In the follows, we test Chemmanur and Fulghieri's theory from another angle. If a firm's value is more difficult to evaluate, the amount of private information remained in the market should be larger. This implies that informed trading in its stock should be more intense. If a firm of this type will choose open offers, then the permanent impacts of informed trades of the open-offer stocks should be higher than those of the rights-offer stocks. We construct the following hypothesis:

$$H_0 : \beta_{1t} = \beta_{5t} \text{ and } \beta_{2t} = \beta_{6t}$$

$$H_1 : (\beta_{1t} > \beta_{5t}) \text{ or } (\beta_{2t} > \beta_{6t})$$

H_0 hypothesis says there is no difference of permanent impacts of trades between the open-offer stocks and rights-offer stocks. H_1 says there is difference between them. We only compare the permanent impacts before equity offers because the pre-offer information characteristic is a better approximation of the information environment where a firm decides its flotation-method choice. The results are summarized in *Table 13*.

For all $t \in [1, 5]$, $\beta_{1t} > \beta_{5t}$ and $\beta_{2t} > \beta_{6t}$. This suggests the magnitude of the permanent impacts seems to be larger for the trades of open-offer stocks than those of rights-offer stocks. However, except $\beta_{22} > \beta_{62}$, none of differences is significant.

Even though $\beta_{22} > \beta_{62}$, we favour to use $t = 5$ to compare the permanent impacts since market makers' updating behaviour may be different for the two types of stocks. For an instance, $\beta_{22} > \beta_{62}$ may be simply because market makers are more sensitive to trades of the open-offer stocks and update their beliefs quicker.

Since there is no significant difference in the permanent impacts of trades when t gets larger, we would accept the H_0 hypothesis. That is, our finding does not support the intuition that firms with more private information are more likely to choose open offers.

Table 13. Comparison of information content of trades between open offer and rights offer stocks

Excess Return Window	PRE/POST	Median/Large trades	Permanent impact of open offer stocks	Permanent impact of rights offer stocks	Significance of the difference between open-offer stocks and rights offer stocks
			T Statistics below	T Statistics below	T statistics (one-sided P value below)
(From - 5 trade to +5 trade)	PRE	Median	0.355% 13.52	0.337% 5.71	0.28 0.39
		Large	0.477% 12.72	0.422% 5.07	0.62 0.27
(-4, +4)	PRE	Median	0.314% 14.17	0.302% 5.92	0.23 0.41
		Large	0.439% 13.66	0.373% 5.26	0.87 0.19
(-3, +3)	PRE	Median	0.263% 14.62	0.223% 5.47	0.92 0.18
		Large	0.376% 14.13	0.328% 5.70	0.76 0.22
(-2, +2)	PRE	Median	0.206% 14.84	0.178% 5.96	0.88 0.19
		Large	0.317% 15.49	0.241% 5.58	1.60 0.05
(-1, +1)	PRE	Median	0.123% 14.54	0.108% 6.01	0.77 0.22
		Large	0.225% 15.61	0.196% 6.84	0.91 0.18

3.5.3.5 Human intermediation in London SEAQ, “Stick” or “Carrot”

LSE is famous for its liquidity provision. Large trades can be efficiently accommodated. Human intermediation is an essential factor that contributes to this feature. In a human intermediated market, a small group of participants repeatedly and un-anonymously trade

with each other in a long-term basis. Reputation building is encouraged. Cooperation between market makers and investors becomes easier to achieve. When market makers and investors cooperate in the process of price discovery, adverse selection can be effectively controlled. Liquidity provision becomes less costly. Large block trades can be accommodated without too much adverse price effects.

Theoretical literature provides two types of explanations on how human intermediation reduces the burden of asymmetric information. Garmill (1989) argues that market makers can heighten competition among informed traders by compensating, through price improvement, only the first one to reveal private information. Benveniste et al. (1992) argues that market makers can mitigate the effects of asymmetric information by improving price for those traders with good reputation of not harming market makers with private information. We call the first one “Carrot” version human intermediation, and the second one “Stick” version.

To understand how human intermediation works in London SEAQ, we investigate the relation between the informative-ness of a trade and its execution quality. If market makers provide a better execution when a trade potentially gets more informative, we tend to accept that market makers encourage informed traders to share information with them by offering price improvement and human intermediation works in a “Carrot” format. On the contrary, if execution quality gets worse when a trade potentially gets more informative, we tend to accept that human intermediation works in a “Stick” format.

Execution quality of a trade is measured by the trade’s total price impact (the effective half spread).⁶¹ In our previous analysis, we have established some differences in the informative-ness of trades between relevant trade-categories. For example, for both types of stocks, large purchases are more informative than median purchases in both the pre-offer and the post-offer period. For both types of stocks, median trades are less informative post equity offers. To find out market makers’ attitude towards informed trading, we may investigate the relation between the change in permanent impacts of trades across relevant categories and the change in total price impacts across these categories. If the changes in permanent impacts and total impacts move in the same direction, we tend to accept that human intermediation works in a “stick” format. Otherwise, “carrot” format. We admit that the following analysis is rather informal. Our object is to raise a meaningful hypothesis for further research.

⁶¹Total price impact is measured by the cumulative abnormal return at trade t .

For the open-offer stocks, large purchases are more informative than median purchases in both event periods. From Table 14, Panel 1-A, we find that large purchases, despite their higher informative-ness, on average obtain better execution than median purchases. In the pre-offer period, the total price impact of large purchases is 1.92%, and that of median ones is 2.08%. The difference, 0.16%, is significant. In the post-offer period, the total price impact of large purchases is 2.24%, and that of median ones is 2.73%. The difference, 0.5%, is highly significant.

During equity offers, information content of median trades drops. From Panel 1-B, we can see that the total price impact of median trades of open-offer stocks changes in the opposite direction during equity offers: the total price impact is higher when information content of trades decreases. For median purchases, the total price impact in the pre-offer period is 2.08%, and that in the post-offer period is 2.73%. The difference, -0.66%, is highly significant. For median sales, the pre-offer total price impact is -2.17%, and the post-offer one is -2.52%, the difference, -0.36%, is highly significant.

These suggest that for open-offer stocks, market makers offer better executions when trades potentially get more informative. This is consistent with the “carrot” version of human intermediation: market makers encourage informed traders to share private information with them by offering better execution.

For the rights-offer stocks, the pattern is not clear. Compared with that of median purchases, the total price impact of large purchases is smaller in the pre-offer period, and is larger in the post-offer period. But the differences are not significant. Across the two event periods, the total price impact of median purchases remains pretty the same. The total price impact of median sales gets significantly smaller post equity offers: the total price impact drops from -1.56% to -1.34%, and the difference, 0.22%, is significant. That is, the execution quality of median sales gets better when they become less informative. This is an evidence of “stick” version of human intermediation: market makers offer price improvement to traders with a reputation of liquidity trading. Overall, we lack of evidences to establish the pattern of human intermediation for the rights-offer stocks.

It is interesting that the patterns of human intermediation appear to be different between the two types of stocks. From previous analysis, we find that our open-offer firms are generally small ones with relatively small market capitalization, and trading of their stocks are less active than that of rights-offer stocks. Although the previous test does not establish a definite result, information content of trades does seem to be higher in our

open-offer stocks⁶². Based on these, we set up the following hypothesis: human intermediation works in a “carrot” format when private information is more costly to obtain and adverse selection is more severe; it works in a “stick” format when information of a stock can be generated less costly and market makers face less threat from informed trading.

We believe that this hypothesis does not lack of theoretical basis. For large well known firms, there is less uncertainty in their operations; information necessary to evaluate their values is available cheaply since they are followed by more analysts; the difficultness of evaluation tends to be low since they are likely to engage in stable industries. Market makers are able to produce information about them efficiently. Therefore it is not necessary for market makers to maintain relation with informed traders by offering “bonus” to them. On the contrary, for small young firms, there tends to be more uncertainty in their operations; information about them is not widely disseminated and is not costless-ly available since they tends to be closely held and are less focused by analysts; their value tends to be more difficult to evaluate since they may engage in high-tech industries. It is not efficient or even not possible for market makers to produce information about these firms solely by themselves. An alternative for market makers is to build relation with informed traders and offer “bonus” to those who supplies them private information.

3.5.4 Summary for Section 3.5

For both the open-offer and the rights-offer stocks, information content of median trades decreases after equity offers. Given that the information content of large trades insignificantly decreases, we conclude, weakly, that asymmetric information is resolved with equity offers. Together with Armitage and Snell (2003)’s finding of positive price effects of UK open offer and negative price effects of rights offers, our result suggests that asymmetric information is resolved with firms’ choices of equity flotation methods, and that UK open offers are employed by good firms to signal quality.

In London SEAQ, information content of trades is related to trade size. Small trades, both purchases and sales, both of the open offer stocks and of the rights offer stocks, and both in pre-offer and post-offer period, have no permanent impacts on price, while median and large trades have significant permanent price impacts.

⁶² Permanent impacts are uniformly larger from trade 1 to 5 for open-offer stocks than rights-offer stocks. Some are significant. A complete table is provided in the appendix.

However, a trade's information content may not increase universally with its size. Large purchases have significantly larger permanent impacts on price than median purchases, both of open-offer stocks and of rights-offer stocks, and both in pre-offer and in post-offer period. On the other hand, large sales are not more informative than median sales. Especially, for the sales of the rights-offer stocks in pre-offer period, large sales' permanent impacts are even smaller than those of median sales, although the difference is not significant.

For the comparison between purchases and sales, large purchases tend to have more information content than large sales. The difference is significant or marginally significant for the open-offer stocks and the pre-offer rights-offer stocks. In contrast, in the median-size category, the asymmetric between purchases and sales goes the other way around: median sales tend to have larger absolute permanent impacts than median purchases. The difference is significant or marginally significant for the open-offer stocks and the pre-offer rights-offer stocks.

Our results suggest that informed traders handle large purchases and large sales with different strategies: when they attempt a large informed purchase, they tend to directly negotiate with market makers and make a block transaction; when they attempt a large informed sale, they may try to conceal their identities, and break down the block order into median ones and off-load them bit by bit by taking market makers' quotes. Our results also implies that market makers are less harsh to traders with positive private information.

The magnitude of the permanent impacts seems to be higher for the trades of open-offer stocks than those of rights-offer stocks. However, the difference is not significant. Therefore, our finding does not support the intuition that firms with more private information are more likely to choose open offers.

For open-offer stocks, market makers offer better executions when trades potentially get more informative. For rights-offer stocks, it seems that market makers offer better executions when trades potentially get less informative. Since informative-ness of trades of open offer stocks seems to be higher than that of rights offer stocks, we set up the following hypothesis: human intermediation works in a "carrot" format when private information is more costly to obtain and adverse selection is more severe; it works in a "stick" format when information of a stock can be generated less costly and market makers face less threat from informed trading.

3.6 Conclusions

In the context of UK open offers and rights offers, we find that information content of trades marginally significantly falls after both rights offers and open offers, which suggests resolution of asymmetric information with equity offers. Together with Armitage and Snell (2003)'s finding of positive price effects of UK open offer and negative price effects of rights offers, our result suggests that asymmetric information is resolved with firms' choices of equity flotation methods, and that UK open offers are employed by good firms to signal quality.

In London SEAQ, information content of trades is related to trade size. Small trades are not informative, while median trades and large trades are informative. However, a trade's information content may not increase universally with its size. Large purchases are more informative than median purchases, while the difference in informative content between large sales and median sales is not significant. For the comparison between purchases and sales, large purchases are more informative than large sales, while median purchases are less informative than median sales. These results suggest that informed traders handle large purchases and large sales with different strategies: when they attempt a large informed purchase, they tend to directly negotiate with market makers and make a block transaction; when they attempt a large informed sale, they may try to conceal their identities, and break down the block order into median ones and off-load them bit by bit by taking market makers' quotes. Our results also imply that market makers are less harsh to traders with positive private information.

With some preliminary evidence, we set up a hypothesis of the pattern of human intermediation in London SEAQ: human intermediation works in a "carrot" format when private information is more costly to obtain and adverse selection is more severe; it works in a "stick" format when information of a stock can be generated less costly and market makers face fewer threats from informed trading.

With our empirical results, we claim that decomposing spread models should not be applied to analyse a market with high degree of human intermediation. The hypothetical information revealing strategies embedded in these models are too naive to capture the actual price discovery process in such a market. Instead, we favour the price impact method since it does not arbitrarily impose any restrictions on market makers' behaviour. This is important for the application in a market with high degree of human intermediation since human intermediation enables a wide range of information revealing

strategies for market makers. Although the price impact method is not a structural model, it can serve as a first-stage procedure and disclose the major behaviour patterns of market makers. A properly constructed decomposing spread model should be built based on the information obtained in the first stage.

Firm size, inverse of price and volume have significant explanatory power on the cross-sectional variation of all our 4 percentage spread measures. Larger firm sizes are associated with lower percentage spreads; higher stocks prices are associated with lower percentage spreads; higher trading volumes are associated with lower percentage spreads. Volatility has significant explanatory power on the cross-sectional variation of our 2 percentage quoted spread measures. With higher volatility, wider quoted spread. However, it has no significant explanatory power on the cross-sectional variation of our 2 percentage effective spread measures. This result suggests that actual transaction prices are less influenced by adverse selection. With the fact that transaction prices are better than quoted prices, this suggests human intermediation alleviates adverse selection problem and facilitate liquidity provisions.

Price changes and volume changes have significant explanatory power on the changes of spreads during equity offers. Significantly negative coefficients of price changes suggest that when price goes up, market makers do not enlarge spreads, or at least do not enlarge it to accompany the price increases. Volume seems to be an important variable for market makers to update their beliefs about a stock's liquidity characteristics. Significantly negative coefficient of volume suggests that when a stock becomes more liquid, market makers ask for less compensation for providing liquidity.

Quoted spread measures, time weighted or not, are larger than effective spread measure, volume weighted or not. This suggests that transaction prices are better than quoted prices. Quoted spread measures tend to exaggerate trading costs in London SEAQ.

Chapter 4

Hold Up with Endogenous Outside-Option

4.1 Introduction

The hold-up problem arises when a party has to make sunk relationship specific investments of which the return is vulnerable to ex-post expropriation by the party's trading partner. Facing the potential of being held up, the party may be reluctant to make socially desirable investments (see Klein, Crawford, and Alchian (1978) for discussion and Grout (1984) for the first formalization).

The inefficiency generated by the hold-up problem has motivated much of the modern contract theory and organizational theory. These theories presume that to encourage relationship specific investments, a transaction relationship has to be effectively governed in the sense that a party's right to his investment return is protected.⁶³ They study the hold-up problem in an environment where comprehensive contracting is impossible and therefore allocation of control or power bears significance. Various remedies to hold-up have been proposed, ranging from vertical integration (Klein, Crawford, and Alchian (1978), and Williamson (1985)), allocation of asset ownership (Grossman and Hart (1986), and Hart and Moore (1990)), contractual renegotiation design (Chung (1991), and Aghion, Dewatripont and Rey (1994)), option contracts (Noldeke and Schmidt (1995, 1998)), production contracts (Edlin and Reichelstein (1996)), relational contracts (Baker, Gibbons and Murphy (2002)), to hierarchical authority (Aghion and Tirole (1997)).

The main purpose of this paper is to re-examine the formalization of the hold-up problem. We depart by allowing a party to dedicatedly invest in his outside option in order to capture its value. Our departure is based on two presumptions. First, relationship specific investments per se are not sufficient for a party to create and realize the value of his outside option. Second, the party is able to separately work on its value. These contrast with most of the previous formalization of hold-up where relationship specific investments are sufficient for outside option values and thus the option to invest outside

⁶³ Che and Sakovics (2004) challenge this usual presumption. By allowing for investment dynamics, they find that the hold-up problem need not entail underinvestment when the parties are sufficiently patient.

is superfluous. For example, in the Fisher Body v. GM case, Fisher Body had to make an investment highly specific to GM in the stamping machines and dies necessary to produce the automobile bodies demanded by GM. Previous works on hold up presume that although the investment by Fisher Body was less valuable outside the Fisher-Body-and-GM relationship, it had effectively created a value in Fish Body's outside option: by investing in the production relationship with GM, Fisher Body was ready to supply to other manufacturers. Rather differently, we presume that if Fisher Body wanted to supply to manufacturers other than GM, he could and would have to invest to re-configure his production process so as to accommodate the needs of other manufacturers.

In an ideal world where transaction parties behave cooperatively, Fisher Body would not make these additional investments since they were not productive. However, facing the risk of being held-up by GM, Fisher may invest for self-protection, since if GM attempted to renegotiate a lower price by threatening to reduce demand or terminate his supply completely, he could switch to produce for other firms. Thus by allowing a party to invest in his outside option, we find an extra source of inefficiency in the hold-up problem: parties may make unproductive investments for bargaining power to avoid being held-up.

Klein, Crawford, and Alchian (1978) had elaborated a related idea: "*...the presence of possible opportunistic behaviour will entail costs as real resources are devoted to the attempt to improve bargaining positions in the event such opportunism occurs.*" There is subtle difference between this argument and ours. While we focus on the ex-ante investment stage, Klein, et al. emphasize the ex-post bargaining stage. They assert that in the presence of the hold-up problem, the ex-post bargaining is costly because parties will engage in inefficient behaviours such as searching for informational advantage over their trading partners (Klein (1988)). Despite the difference, underlying these two arguments is the premise that absent an effective governing mechanism, parties to a long-term relationship will engage in socially undesirable behaviours to protect themselves against other parties' opportunistic behaviours.

Appealing as it is, the formal analysis of the hold-up problem seems to pay little attention to this premise. For the sake of our theme, we focus on the ex-ante investment stage. For example, in the hold-up problem set down by Grossman and Hart (1986), transaction parties are not allowed to separately invest in their outside options, and the values of their outside options are merely a by-product of the parties' relationship specific investments. Since a party's outside option provides bargaining strength during

ex-post negotiation, the party has extra incentives to make relationship specific investments and the existence of outside option partially offsets the underinvestment problem induced by hold-up.

We claim that this type of formulation of hold-up is incomplete. The missing part is that outside option can actually be a source of non-cooperative and inefficient behaviours. Consider the following example. A buyer purchases an intermediate good from a seller. The good worth 60 if the seller invests, while nothing if not. The investment cost is 10. After the seller makes investment choices, they bargain over the surplus with the equal bargaining strength. Nash bargaining solution is employed to determine the payoffs. In this scenario, the hold-up problem does not create inefficiency. Although being held-up by the buyer, the seller still capture a positive return from his investment, $30 - 10 = 20$. Now imagine that the seller can separately invest 10 to generate a value of 40 in his outside option. Assume that he can only trade either with the buyer or with his outside customer. Inefficiency arises: the seller will make both investments. The social surplus drops from $60 - 10 = 50$ to $60 - 10 - 10 = 40$. The second investment from the seller is just to accumulate bargaining strength, and is not productive at all. If we further consider some realistic assumptions: for example, the seller has limited wealth of 15, the outcome will be even worse. He will give up the socially efficient relationship with the buyer and the social surplus drops further to $40 - 10 = 30$.

In a stylized setting, we will show that after considering the possibility of separately investing in outside option, the hold-up problem is potentially more severe than previously observed. Parties to a transaction may make investments which are not productive in social point of view. More importantly, the inefficient investment may even crowd out relationship specific investments, which may result in relationship-breaking in a socially efficient relationship.

The second purpose of this paper is to justify the use of exclusive contracts. A contract is said to be exclusive if it prohibits at least one party to the contract from trading with outside parties. There are two opposite views of the role played by exclusive contracts. The opponents argue that they serve anticompetitive purposes by erecting a barrier to the entry of competitors (Aghion and Bolton (1987), Bernheim and Whinston (1998), and Segal and Whinston (2000b)). The advocates claim that exclusive contracts can be efficiency enhancing when exclusive-rights holders are the important investing parties. The reason they provide is that exclusive contracts enhance the protected parties'

bargaining position, and consequently they are less exposed to the hold-up problem and have more incentive to make relationship specific investments (Marvel (1982), Klein (1988), Masten and Snyder (1993) and Mathewson and Winter (1994)). Segal and Whinston (2000a) formally study the effect of exclusive contracts on investment incentive. They find that exclusive contracts do offer the protected parties a larger share of surplus. However, when the parties' investments are fully specific to the relationship, exclusive contracts are neutral to investment incentive.⁶⁴ On the contrary, if the investments have external effects, exclusivity matters.

Based on our set-up, we find that exclusive contracts can affect investment incentive. The presence of exclusivity sufficiently reduces the sensitivity of a party's payoff to his investment in his outside option. As long as his investment in the outside option is less productive than his relationship specific investment, his incentive to invest outside will be wiped out. Our finding does not contradict the *Irrelevance result* in Segal and Whinston (2000a) since a party's investment in our setup can be purely external. Furthermore, we find that exclusivity improves efficiency when relationship specific investments are sufficiently productive, but worsens it when they are sufficiently unproductive.

After we finished this paper, we found that Baker, Gibbons and Murphy (2002) also allow separately investing in outside option. However, they did not study the interaction between relationship specific investments and investments in outside option. Moreover, their assumptions preclude the case of relation-breaking: overall surplus in a relationship is always above that in parties' outside option.

The paper is organized as follows: in section 1.1, we briefly review the hold-up problem and the incentive effects of exclusive contracts. In section 2, we provide a model to address the effect of allowing for separate investments in outside option. In section 2.1, we analyze how exclusive contracts can solve the inefficiency induced by this investment option. Section 3 concludes the analysis.

4.1.1 A brief review of the Literature

4.1.1.1 Hold-up problem

When two parties enter into a long-term relationship, they often have to make investments which are geared towards their partners. This type of investments, referred

⁶⁴ De Meza and Selvaggi (2003) show that this irrelevant result does not hold if ex-post bargaining is non-cooperative.

by the literature as relationship specific investments, is less valuable outside the relationship. Once the investments are sunk, a party can not rely on the market to discipline his partner, and his investments return will be vulnerable to expropriation. This problem, known as hold-up, will discourage parties from making socially desirable investments.

Consider the following case. A buyer purchases one unit of goods from a seller. The gross surplus of this trade, ϕ , is random and can take two value: ϕ^L or ϕ^H . The buyer can make non-contractible relationship specific investment, $x \in [0,1]$, to enhance the expected surplus: with probability x the surplus is ϕ^H , and with the remaining probability the surplus is ϕ^L . The investment cost is $c(x)$. Assume $c' > 0$, $c'' > 0$ and $c(0) = 0$.

After the investment is made, the value of ϕ realizes and the two parties bargain over surplus with equal bargaining strength. Nash bargaining solution is employed to determine the payoffs.

The social optimal investment is,

$$x^* = \arg \max_x \phi^L + x(\phi^H - \phi^L) - c(x)$$

Assume an interior solution: $x^* > 0$.

The buyer assumes all the ex-ante investment cost, while can not prevent the seller from sharing his investment return. His optimal investment choice is,

$$\hat{x} = \arg \max_x \frac{1}{2}\phi^L + \frac{x}{2}(\phi^H - \phi^L) - c(x)$$

Clearly the hold-up problem causes under-investment: $\hat{x} < x^*$.

4.1.1.2 Exclusive contracts and investment incentive

Advocates of exclusive contracts mostly discuss its beneficial effects in the hold-up frameworks. They claim that exclusive contracts can enhance an exclusive-right holder's ability to protect his relationship specific investment against opportunistic hold-up, and thus encourage him to make socially desirable investments. Most of the informal discussions explain exclusivity as a device to eliminate horizontal or vertical externalities of parties' relationship specific investments. Areeda and Kaplow (1988) and Mathewson and Winter (1994) focus on the case of horizontal externalities: a party's investment can

be used by his outside competitors to deal with the party's partner in the relationship. Mathewson and Winter (1994), for example, suggest that a franchisor can provide incentives for his franchisee to invest in local promotions by granting him exclusive territories which excludes non-investing outlets from sharing benefits. Marvel (1982) and Masten and Snyder (1993) focus on the case of vertical externalities: a party's investment can be used by his trading partner to deal with outside parties. Marvel (1982), for example, comments on the case *Standard Fashion Co. v. Magrane-Houston Co.* that exclusivity had an efficiency rationale since the pattern manufacturer, *Standard Fashion Co.*, could not protect its property rights to successful pattern design if its dealers could handle the products from its rivals. The reason is that its dealers were able to switch customers to similar patterns offered by its rivals who could make no investments on fashion designs but just copy the designs that proved to be successful. Different from above, Klein (1988) and Frasco (1991) claim that exclusive contracts can be a substitute for quantity contracts to protect a party's relationship specific investments when specification of quantity is too costly. Klein (1988), for example, suggest that the long-term exclusive dealing contract adopted by Fisher Body and GM in 1919 limited the ability of GM to hold-up Fisher Body by threatening to reduce demand for Fisher-produced car bodies.

To examine the effect of exclusive contracts, we introduce an outside buyer into the picture. Ex-post, the seller can supply the good to the outside buyer. The surplus generated by this trade is θ . To make the story interesting, assume $\phi^L < \theta < \phi^H$. Assume that the seller can either supply to the inside buyer or the outside buyer, but not both.

Ex-ante, the inside buyer and the seller can enter into an exclusive contract which stipulate that ex-post, the seller can only supply to the inside buyer.⁶⁵ Assume that this contract is renegotiable.

Ex-post, the three parties bargain over the surplus. The bargaining process can be modelled with cooperative game theory or non-cooperative game theory. Segal and Whinston (2000a) and De Meza and Selvaggi (2003), each with a different type of bargaining game, provide formal analyses of the incentive effect of exclusive contracts. The main finding of Segal and Whinston (2000a) is an *Irrelevance result* that exclusivity does not matter when all investments are fully specific to the relationship. However, this result does not hold when ex-post bargaining is non-cooperative (De Meza and Selvaggi

⁶⁵ The inside buyer can make a lump-sum payment to the seller so as to induce him into this arrangement.

(2003)). In what follows, we separately apply cooperative bargaining game and non-cooperative bargaining game to reproduce their results with our simple model.

Cooperative Bargaining

As in Segal and Whinston (2000a), the Shapley value is employed to determine parties' shares of surplus: each party's payoff is a linear function of his marginal contribution to the various possible coalition in which he can be a member. Symmetric property is imposed.

The three-party bargaining outcome is summarized in what follows:⁶⁶

⁶⁶ We demonstrate the calculation of the Shapley value for state ϕ^L . We label the seller as S , the inside buyer as B , and the outside buyer as O .

When there is no exclusive contract, B marginally contributes ϕ^L to coalition $\{S\}$, 0 to $\{O\}$, and 0 to $\{S, O\}$. The last one is 0 because the seller and the outside buyer by themselves can generate surplus θ which is greater than ϕ^L . Since the seller can only supply to one buyer, B 's joining $\{S, O\}$ does not create any surplus. S contributes ϕ^L to coalition $\{B\}$, θ to $\{O\}$, and θ to $\{O, B\}$. O contributes θ to coalition $\{S\}$, 0 to $\{B\}$, and $\theta - \phi^L$ to $\{S, B\}$. With these, the parties' bargaining payoffs can be put down as,

$$V_S = \alpha_S^B \phi^L + \alpha_S^O \theta + \alpha_S^{BO} \theta$$

$$V_B = \alpha_B^S \phi^L + \alpha_B^O \times 0 + \alpha_B^{SO} \times 0$$

$$V_O = \alpha_O^S \theta + \alpha_O^B \times 0 + \alpha_O^{BS} (\theta - \phi^L)$$

The superscript of α denotes a coalition, and the subscript denote a member outside the coalition. For example, α_S^{BO} is the weight we put on the marginal contribution of S to the coalition $\{B, O\}$. α is chosen such that $V_S + V_B + V_O = \theta$. That is, the sum of individual payoff equal the overall surplus generated by the whole group. This requires,

$$\alpha_O^S + \alpha_S^O + \alpha_S^{BO} + \alpha_O^{BS} = 1 \text{ and } \alpha_S^B + \alpha_B^S = \alpha_O^{BS}$$

Apply symmetric property, we have $\alpha_O^S = \alpha_S^O = \alpha_S^B = \alpha_B^S = 1/6$, and $\alpha_S^{BO} = \alpha_O^{BS} = 1/3$. Put these back to

the above equations about V . We get $V_S = \frac{\theta}{2} + \frac{\phi^L}{6}$, $V_B = \frac{1}{6} \phi^L$, and $V_O = \frac{1}{2} \theta - \frac{1}{3} \phi^L$.

When the seller and the inside buyer sign an exclusive contract, B marginally contributes ϕ^L to coalition $\{S\}$, 0 to $\{O\}$, and θ to $\{S, O\}$. Notice that under exclusivity, the coalition $\{S, O\}$ can no longer generate any surplus. The reason is that without the inside buyer's permission, the seller can not trade with the outside buyer. Only after B is involved, the optimal surplus θ can be realized.

When the seller and the inside buyer did not sign an exclusive contract, the ex-post bargaining payoffs for the seller, the inside buyer and the outside buyer respectively are:

$$\text{In state } \phi^L: \frac{1}{2}\theta + \frac{1}{6}\phi^L, \frac{1}{6}\phi^L, \frac{1}{2}\theta - \frac{1}{3}\phi^L$$

$$\text{In state } \phi^H: \frac{1}{2}\phi^H + \frac{1}{6}\theta, \frac{1}{2}\phi^H - \frac{1}{3}\theta, \frac{1}{6}\theta$$

Given x , the inside buyer's expected ex-post payoff is,

$$V_B^{NE} = (1-x)\frac{1}{6}\phi^L + x(\frac{1}{2}\phi^H - \frac{1}{3}\theta) = x(\frac{1}{2}\phi^H - \frac{1}{3}\theta - \frac{1}{6}\phi^L) + \frac{1}{6}\phi^L$$

When there is an exclusive contract between the inside buyer and the seller, the bargaining payoffs to the seller, the inside buyer and the outside buyer respectively are:

$$\text{In state } \phi^L: \frac{1}{3}\theta + \frac{1}{6}\phi^L, \frac{1}{3}\theta + \frac{1}{6}\phi^L, \frac{1}{3}(\theta - \phi^L)$$

$$\text{In state } \phi^H: \frac{\phi^H}{2}, \frac{\phi^H}{2}, 0$$

Given x , the inside buyer's expected ex-post payoff is,

$$V_B^E = (1-x)(\frac{1}{3}\theta + \frac{1}{6}\phi^L) + x\frac{1}{2}\phi^H = x(\frac{1}{2}\phi^H - \frac{1}{3}\theta - \frac{1}{6}\phi^L) + \frac{1}{6}\phi^L + \frac{1}{3}\theta$$

Comparing these two cases, we can see that when the inside buyer is protected by an exclusive contract, he does obtain a larger share of surplus. This is consistent with the conventional wisdom on the effect of exclusivity. The increment of his surplus, $\frac{1}{3}\theta$, is extracted from the seller and the outside buyer.

However, since the increment, $\frac{1}{3}\theta$, is not sensitive to his relationship specific investment, exclusive contracts do not improve the inside buyer's investment incentive:

$$x^{NE} = \arg \max_x \frac{1}{6}\phi^L + x(\frac{1}{2}\phi^H - \frac{1}{3}\theta - \frac{1}{6}\phi^L) - c(x)$$

S marginally contributes ϕ^L to coalition $\{B\}$, θ to $\{O\}$, and θ to $\{O, B\}$. O contributes θ to coalition $\{S\}$, θ to $\{B\}$, and $\theta - \phi^L$ to $\{S, B\}$.

Following the same methodology, the payoffs for S , B , and O can be obtained:

$$V_S = \frac{1}{3}\theta + \frac{1}{6}\phi^L, V_B = \frac{1}{3}\theta + \frac{1}{6}\phi^L, \text{ and } V_O = \frac{1}{3}(\theta - \phi^L).$$

Similarly, the bargaining outcome for state ϕ^H can be obtained.

$$x^E = \arg \max_x \frac{1}{3}\theta + \frac{1}{6}\phi^L + x(\frac{1}{2}\phi^H - \frac{1}{3}\theta - \frac{1}{6}\phi^L) - c(x)$$

$$x^E = x^{NE}$$

This is not consistent with Klein (1988) and Frasco (1991)'s argument on the incentive effect of exclusive contracts.⁶⁷

Segal and Whinston (2000a) in a more general setup prove an *Irrelevance result*: when parties' investments are fully specific to the relationship, exclusive contracts do not affect parties' investment incentive. The idea is that exclusive contracts only affect the surplus generated between an inside party and an outside party. When this surplus is insensitive to parties' investment, exclusivity does not affect the marginal returns of investments for any parties. For example, in Klein (1988)'s discussion of Fisher Body v. GM, it is far from clear that Fisher Body's relationship specific investments has external effects: GM is better able to purchase from other car-body manufacturers, or other manufacturers can produce car bodies more efficiently. Therefore, exclusivity may probably not affect Fisher's investment incentives.

On the other hand, if parties' investments have external effects, exclusive contracts will matter for investment incentive. Assume θ is an increasing function of x , with $\phi^L < \theta(0) < \theta(1) < \phi^H$. That is, the inside buyer's investment affects the value of trades between the seller and the outside buyer. For example, suppose that the seller is a manufacturer and the inside buyer is his distributor. The buyer's promotional efforts are specific to the seller's product, but they have horizontal externality since other distributors of the same good can free-ride on them. In this case, holding an exclusive-right (exclusive territories) can encourage the inside buyer's promotional efforts:

$$x^{NE} = \arg \max_x \frac{1}{6}\phi^L + x(\frac{1}{2}\phi^H - \frac{1}{3}\theta(x) - \frac{1}{6}\phi^L) - c(x)$$

$$x^E = \arg \max_x \frac{1}{3}\theta(x) + \frac{1}{6}\phi^L + x(\frac{1}{2}\phi^H - \frac{1}{3}\theta(x) - \frac{1}{6}\phi^L) - c(x)$$

Since $\theta'(x) > 0$, $x^E > x^{NE}$.

⁶⁷ In Klein (1988)'s discussion of Fisher Body v. GM, it is the seller, Fisher Body, that makes investments. But this does not affect the conclusion.

Non-cooperative bargaining

The ex-post bargaining is modelled with Rubinstein (1982) alternative offer game. Time is divided into periods of equal length, $0, t, 2t, 3t, \dots$. There is no time discount for all parties but a risk of breakdown in negotiation at the end of each period.

In period 0 , the seller is matched with the efficient buyer (in state ϕ^L , the outside buyer; in state ϕ^H , the inside buyer). A proposer is selected randomly with equal probability. The other party can accept or reject the proposal. In the case of acceptance, the good is immediately transferred. If the proposal is rejected, bargaining may either break down, or move to the next period where the seller is matched the other buyer and the cycle is repeated.

If the seller reaches agreement with the efficient buyer, the bargaining ends immediately. If he reaches agreement with the inefficient buyer, in the following period, the inefficient buyer can negotiate with the efficient buyer to resell the good. In the resale sub-game, the bargaining is again modelled with alternative offer game with random proposer and a change of breakdown at the end of each round.

Apply the *Proposition 1, 2, 3* of De Meza and Selvaggi (2003): when the inside buyer is not protected by an exclusive contract, in the limit as $t \rightarrow 0$, the unique sub-game perfect equilibrium payoffs of the seller, the inside buyer and the outside buyer respectively converge to,

$$\text{In the state } \phi^L: \frac{\phi^L + \theta}{2}, 0, \frac{\theta - \phi^L}{2}$$

$$\text{In the state } \phi^H: \frac{\phi^H + \theta}{2}, \frac{\phi^H - \theta}{2}, 0$$

While the inefficient buyer obtains a positive payoff with cooperative bargaining, he gets nothing here. The two buyers behave symmetrically despite the fact that they have different valuation: they will offer the seller the same price which is exactly the price in the resale market. This makes the seller indifferent between dealing with either buyer.

When the inside buyer is protected by an exclusive contract, in the limit as $t \rightarrow 0$, the unique sub-game perfect equilibrium payoffs of the seller, the inside buyer and the outside buyer respectively converge to,

$$\text{In the state } \phi^L: \frac{\phi^L + \theta}{4}, \frac{\phi^L + \theta}{4}, \frac{\theta - \phi^L}{2}$$

In the state ϕ^H : $\frac{\phi^H}{2}, \frac{\phi^H}{2}, 0$

We can see that the inside buyer obtains higher payoffs in both states. The increment of his surplus is solely extracted from the seller, but not from the outside buyer.

The inside buyer's investment incentive depends on the increment of surplus from state ϕ^L to ϕ^H . When he holds no exclusive rights, the increment is $\frac{\phi^H - \theta}{2}$; when he

holds the rights, it is $\frac{\phi^H}{2} - \frac{\phi^L + \theta}{4} = \frac{\phi^H - \frac{\phi^L + \theta}{2}}{2}$. Since by assumption $\theta > \phi^L$, the marginal investment return for the inside buyer is higher when he is protected by an exclusive contract. Therefore, he will invest more.

As what happens under cooperative bargaining, exclusive contracts offer the protected party a larger share of surplus. Given x , the expected payoff of the inside buyer is higher under an exclusive contract: $x \frac{\phi^H}{2} + (1-x) \frac{\phi^L + \theta}{2} > x \frac{\phi^H - \theta}{2}$.

However, the implications on incentive are different in these two analyses. Notice that in our simple model, the inside buyer's investment has no external effect, e.g. the surplus between the seller and the outside buyer, θ , is not sensitive to the investment. According to the *Irrelevance result*, exclusivity should not have incentive effects. It does matter here because exclusivity allows ϕ^L to affect the inside buyer's payoff when he is the inefficient buyer. Absent of exclusivity, the inside buyer is effectively excluded from bargaining in state ϕ^L ; the increment of his payoff from state ϕ^L to state ϕ^H is only related to $\phi^H - \theta$. On the other hand, with exclusivity, the inside buyer's payoff is related to ϕ^L when he is the inefficient buyer; from state ϕ^L to state ϕ^H , the increment of his payoff is now related to both $\phi^H - \theta$ and $\theta - \phi^L$. It is this asymmetric that allows exclusivity to affect incentive: under exclusivity, he has extra incentive $(\theta - \phi^L)$ to achieve state ϕ^H , and thus invests more.

4.1.1.3 Summary of the review

The hold-up problem arises when a party has to make sunk relationship specific investments of which the return is vulnerable to ex-post expropriation by the party's

trading partner. Facing the potential of being held up, the party will be reluctant to make socially desirable investments. Underinvestment problem arises.

When ex-post bargaining is cooperative, exclusive contracts have no effects on investment incentives if parties' investments are fully specific to the relationship. The reason is that exclusive contracts only affect the surplus generated between an inside party and an outside party. When this surplus is insensitive to parties' investment, exclusivity does not affect the marginal returns of investments for any parties. On the other hand, if parties' investments have external effects, exclusivity matters for investment incentives.

When ex-post bargaining is non-cooperative, even if parties' investments are fully specific to the relationship, exclusivity affects investment incentives. Under non-cooperative bargaining, exclusivity allows the protected party's payoff to be sensitive to his investment even when it is not optimal for the party to trade from the social point of view. Therefore, the party will have more incentive to invest if he holds an exclusive right.

4.2 The Model

A buyer and a seller trade to realize profit. The transaction requires relationship specific investments from both parties, which costs C to each party. When both parties invest, the surplus from subsequent trade is $(1+r)\phi$; when only one party invests, it is ϕ ; when none of them invest, 0 .

Assume:

$$\phi > C \quad (4.1)$$

$$r\phi > C \quad (4.2)$$

Under these assumptions, it is efficient for both parties to invest. r is a measure of complementarities of the investments. When $r > 1$, the investments by the buyer and the seller are complementary since the conditional marginal return is higher when the other party invests than that when the other does not. On the other case, they are substitutable. We call the production relation between the buyer and the seller the inside relation.

The seller also has an outside option, say, to produce for a competitive market. He can choose to invest C in this outside option to enhance its value. We could allow the seller's investment in the inside option to affect the value of his outside option. But this would complicate the analysis without offering more insights. Another way to capture this investment externality is by a cost externality, which is embodied in the variable k .

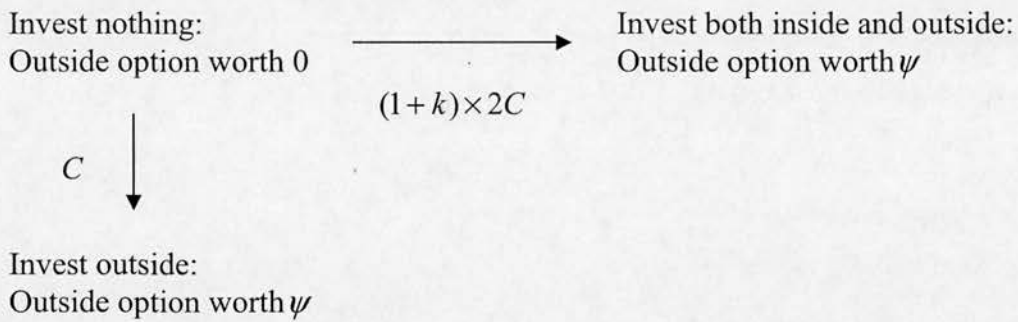
The seller will incur investment cost $(1+k) \times 2C$ if he chooses to invest in both the inside and the outside relation. k captures the investment cost externality. Assume

$$k > -\frac{1}{2} \quad (4.3)$$

A negative k captures the possibility of synergy between the seller's two types of investment. A positive k captures the convexity of the seller's cost function.

To ensure that outside option is not meaningless. Assume:

$$\psi > C \quad (4.4)$$



Assume that due to institutional restriction or production capacity, the seller can either trade inside or outside the relation.

Further assume that the inside relation is more productive than the outside relation:

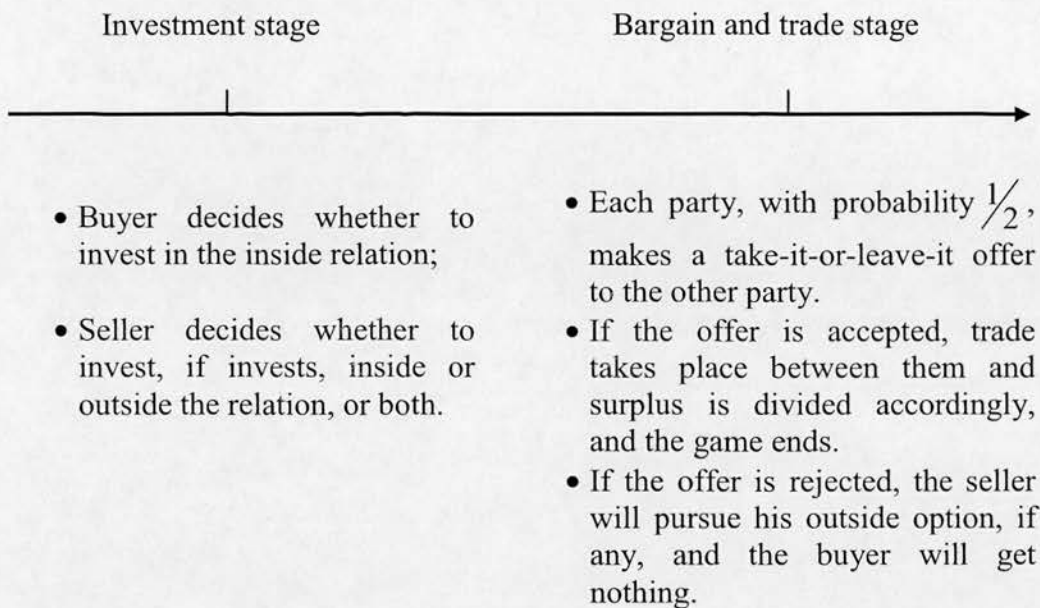
$$\phi > \psi \quad (4.5)$$

With this assumption, it follows that $(1+r)\phi - 2C > \psi - C$. So it is efficient for both parties to invest in the inside relation. The values of ϕ, ψ, C, k , and r are common knowledge.

The trading game is organized as follows. The game has two dates. At date 0, the buyer decides whether to invest in the inside relation; the seller decides whether to invest, if

invests, inside or outside the relation, or both. After they make investment decisions, their investments become sunk and observable to each other, but not to a third party.⁶⁸

At date 1, the buyer and the seller bargain over the surplus of the inside relation. Assume that each party possesses equal bargaining power. Nash bargaining solution is employed to determine the payoffs: each party, with probability $\frac{1}{2}$, makes a take-it-or-leave-it offer to the other party. If the offer is accepted, they trade and divide the surplus accordingly, and the game ends; otherwise, the seller will opt out to pursue his outside option, if any, and the buyer will end up with zero profit.



At investment stage, the seller has four strategies: do not invest, N_s ; invest in the outside relation O_s ; invest in the inside relation, I_s ; invest in both relation, IO_s . The buyer has two strategies: invests in the inside relation, I_b , or does not invest, N_b .

To solve the equilibrium investment strategy of this game, we adopt backward induction: work out the equilibrium in the ex-post bargaining game given each investment choice pair, and then analyze the entire game at ex-ante stage. The solution concept is sub-game perfect equilibrium.

⁶⁸ Some might wonder why there is no initial contracts between the inside parties. We claim that this analysis is more on the hold-up problem per se, but not on contract solution at this stage (we do allow a particular type of contracts, exclusive contracts, later on). Alternatively, we can assume that the nature of the ex-post trade is ex-ante un-describable so that the optimal ex-ante contract is left with null contract (Hart and Moore (1999)).

Proposition 1: The equilibrium bargaining outcomes given each pair of investment choices are as follows:

- (N_S, N_B) : Trade does not occur. The gross expected payoffs to the seller and the buyer are $(0, 0)$.
- (N_S, I_B) : The buyer and the seller trade. The gross expected payoffs are $(\frac{1}{2}\phi, \frac{1}{2}\phi)$.
- (O_S, N_B) : The seller trades outside. The payoffs are $(\psi, 0)$.
- (O_S, I_B) : The buyer and the seller trade. The gross expected payoffs are $(\frac{\phi + \psi}{2}, \frac{\phi - \psi}{2})$.
- (I_S, N_B) : The buyer and the seller trade. The gross expected payoffs are $(\frac{1}{2}\phi, \frac{1}{2}\phi)$.
- (I_S, I_B) : The buyer and the seller trade. The gross expected payoffs are $(\frac{1+r}{2}\phi, \frac{1+r}{2}\phi)$.
- (IO_S, N_B) : The buyer and the seller trade. The gross expected payoffs are $(\frac{\phi + \psi}{2}, \frac{\phi - \psi}{2})$.
- (IO_S, I_B) : The buyer and the seller trade. The gross expected payoffs are $(\frac{(1+r)\phi + \psi}{2}, \frac{(1+r)\phi - \psi}{2})$.

Proof: Complete information bargaining ensures ex-post efficient outcomes. Trade always takes place where the overall surplus is higher.

Given investment choice (N_S, N_B) , there is no surplus either inside or outside the relation. No trade takes place and both parties end up with zero profit.

Given (N_S, I_B) , the surplus in the inside relation is ϕ , which is above that of the outside the relation, 0 . Trade will take place between the buyer and the seller. The buyer, with probability $\frac{1}{2}$, gets the whole surplus ϕ , so does the seller. Therefore, the expected payoffs for the seller and the buyer are $(\frac{1}{2}\phi, \frac{1}{2}\phi)$.

Given (O_S, N_B) , the surplus in the seller's outside relation is ψ , which is above that of the inside relation, 0. The seller will pursue his outside option. The payoffs for them are $(\psi, 0)$.

Given (O_S, I_B) , the surplus in the inside relation is ϕ ; the surplus in the seller's outside relation is ψ . Given that $\phi > \psi$, trade will take place in the inside relation. With probability $\frac{1}{2}$, the buyer makes a take-it-and-leave-it offer to the seller. To make the seller accept his offer, he has to match the seller's outside option and offers at least ψ to seller. With the other probability $\frac{1}{2}$, the seller makes a take-it-and-leave-it offer to the buyer. Since the buyer has no outside option, the seller will get the entire surplus ϕ . Therefore, the expected surplus for the buyer is $\frac{1}{2}(\phi - \psi)$, and that for seller is $\frac{1}{2}\phi + \frac{1}{2}\psi$.

Given (I_S, N_B) , trade will take place in the inside relation, since there is no surplus in the seller's outside relation. Each equal bargaining power, they will split the surplus half and half, which leads to expected payoffs $(\frac{1}{2}\phi, \frac{1}{2}\phi)$.

Given (I_S, I_B) , trade will take place in the inside relation. The overall surplus in the inside relation is $(1+r)\phi$. The buyer with probability $\frac{1}{2}$ gets the entire surplus. So does the seller. Therefore, the expected payoffs for them are $(\frac{1+r}{2}\phi, \frac{1+r}{2}\phi)$.

Given (IO_S, N_B) , the surplus in the inside relation is ϕ . That in the seller's outside option is ψ . Given $\phi > \psi$, trade will take place in the inside relation. When the buyer makes offer to the seller, he has to offer the seller at least ψ for it to be accepted. When the seller makes offer, he gets the entire surplus. The expected payoffs to them are $(\frac{\phi + \psi}{2}, \frac{\phi - \psi}{2})$.

Given (IO_S, I_B) , the surplus in the inside relation is $(1+r)\phi$. That in the seller's outside option is ψ . Given $\phi > \psi$, $(1+r)\phi > \psi$ and trade will take place in the inside relation. With probability $\frac{1}{2}$, the buyer gets $(1+r)\phi - \psi$ and seller gets ψ ; with the other

probability $\frac{1}{2}$, the buyer gets nothing and seller gets $(1+r)\phi$. The expected payoffs to them are $(\frac{(1+r)\phi + \psi}{2}, \frac{(1+r)\phi - \psi}{2})$.

Q.E.D

Given the ex-post bargaining outcomes, we now turn to the ex-ante investment choice problem. Note that the above payoffs have not accounted for the investment costs, since they are already sunk ex-post. While in the ex-ante stage, the buyer and the seller have to take the costs into account when they choose among their investment strategies. Therefore, in the ex-ante stage, the payoff to each player given an investment choice pair should be calculated by subtracting from his payoff at the bargaining stage the cost incurred with his ex-ante investment choice. This yields the following payoff matrix:

		Buyer	
		I_B	N_B
Seller	N_S	$\frac{1}{2}\phi - C$ $\frac{1}{2}\phi$	0 0
	O_S	$\frac{\phi - \psi}{2} - C$ $\frac{1}{2}\phi + \frac{1}{2}\psi - C$	0 $\psi - C$
	I_S	$\frac{1+r}{2}\phi - C$ $\frac{1+r}{2}\phi - C$	$\frac{1}{2}\phi$ $\frac{1}{2}\phi - C$
	IO_S	$\frac{(1+r)\phi - \psi}{2} - C$ $\frac{1+r}{2}\phi + \frac{1}{2}\psi - 2(1+k)C$	$\frac{\phi - \psi}{2}$ $\frac{1}{2}\phi + \frac{1}{2}\psi - 2(1+k)C$

In what follows, we provide some propositions featuring several interesting equilibriums. We are particularly interested in the case when $\phi \geq \frac{2}{r}C$, since when $\phi \geq \frac{2}{r}C$, the social-optimal investment choices, (I_S, I_B) , will be an equilibrium outcome if the seller is refrained from investing in his outside option.⁶⁹

The following propositions and corollaries are provided given that assumptions (4.1) to (4.5) hold.

Proposition 2: (O_S, I_B) is equilibrium if and only if $\phi - \psi$ pair satisfies

$$\text{Max}\left\{\frac{2C}{1-r}, 4C\right\} \leq \phi \leq \frac{2(1+2k)C}{r}, \text{ and } \text{Max}\{r\phi, 2C\} \leq \psi \leq \phi - 2C.$$

Proof: see Appendix B.

Corollary 1: Equilibrium (O_S, I_B) exists only if one of the following sets of conditions is satisfied:

- $-\frac{1}{4} \leq k < 0$ and $r \leq \frac{1}{2} + k$
- $k \geq 0$ and $r \leq 1 - \frac{1}{2(1+k)}$

Proof: see Appendix B.

Graph 4.1 depicts the (O_S, I_B) equilibrium in a $\phi - \psi$ space.

Given that the buyer chooses to invest, in the model's set-up, trade will take place in the inside relation. The seller has four choices: invests nothing and free rides on the buyer's investment; invests in his outside relation to acquire bargaining power for ex-post negotiation; invests in the inside relation to increase the overall surplus; invests in both

⁶⁹ If the seller is refrained from investing in his outside option, he is left with investment choices N_S and I_S . For (I_S, I_B) to be an equilibrium, the seller should have no incentive to deviate to N_S , and the buyer should have no incentive to deviate to N_B . This requires $\frac{1+r}{2}\phi - C \geq \frac{1}{2}\phi$. The sufficient condition for this inequality is $\phi \geq \frac{2}{r}C$.

relations. What he will choose depends on the marginal investment return, the investment cost and the resulting sharing rule.

If the seller chooses to invest in the inside relation, the marginal investment return is $r\phi$. Although by assumption, $r\phi > C$, this may not be a profitable choice for the seller, because he can only capture half of the marginal return, while bears all the investment cost. Unless $\frac{r\phi}{2} - C \geq 0$, investing in the inside relation will be a dominated choice for the seller. Apparently, as the investments in the inside relation becomes more substitutable, the distortion of the seller's incentive due to the hold-up problem becomes more severe.

Instead of to increase the overall surplus, the seller can invest in his outside relation to alter the ex-post sharing rule. The marginal return of investing outside is ψ . By assumption, $\psi > C$. But the seller will not invest outside all the time as $\psi > C$, since the surplus in the seller's outside relation will not be realized ex-post. The outside relation is useful for the seller only because it contributes to his ex-post bargaining power. For we assume equal bargaining power, the marginal contribution of investing outside is $\frac{\psi}{2}$. Unless $\psi \geq 2C$, investing outside will be a dominated choice for the seller.

The interesting case arises when the seller's share of marginal return of his investment in the inside relation is above the cost C and the value of his outside relation is above $2C$. If his inside relation and outside relation display some synergy, say, a negative k , the seller will invest in both relations. But if his cost function is convex (a positive k), it may not be in his interest to invest both. If this is the case, he will have to choose one, depending on which offers him more profit. This gives rise to the following corollary.

Corollary 2: Assume $\phi \geq \frac{2C}{r}$, equilibrium (O_S, I_B) exists only if $k \geq 0$ and $r \leq 1 - \frac{1}{2(1+k)}$.

For such k and r , (O_S, I_B) is equilibrium if and only if $\phi - \psi$ pair satisfies $\frac{2C}{1-r} \leq \phi \leq \frac{2(1+2k)C}{r}$, and $r\phi \leq \psi \leq \phi - 2C$.

Proof: see Appendix B.

A non-negative k is essential to obtain this result. Otherwise, given $\phi \geq \frac{2C}{r}$ and $\psi > 2C$, the seller's shares of investment returns in both relations are positive after taking into account the costs, and it is optimal for him to invest in both.

In the case when the seller has to choose one to invest because of the convexity of his cost function, he will invest in the relation where his investment return is higher. Given equal bargaining power, the seller's investment return in the inside relation is $\frac{1}{2}r\phi$, and that in his outside relation is $\frac{1}{2}\psi$. He will invest outside if and only if $\psi \geq r\phi$ (investment costs are the same for these two choices).

We now turn to the buyer's problem. The buyer has no outside option in this model and his reservation payoff is 0. As long as ex-post trade takes place in the inside relation and his share of surplus at least compensates his investment cost, he will invest ex-ante. This puts an upper bound on the value of the seller's outside option.

Given investment pair (O_S, I_B) , trade always takes place inside the relation. The buyer's share of surplus is $\frac{1}{2}\phi$ if the seller does not invest in his bargaining power. But if the seller invests outside, ex-post he can extract $\frac{1}{2}\psi$ from the buyer. For the buyer to invest ex-ante, his payoff from ex-ante point of view, $\frac{1}{2}\phi - \frac{1}{2}\psi - C$, must be above 0. This boils down to the last inequality in Proposition 1 and Corollary 2.

In terms of welfare, equilibrium (O_S, I_B) is inefficient, not only because the seller does not invest in the inside relation, which he should, but also because he invests in something useless from social point of view. In this equilibrium, the seller's investment is not productive at all since trade never takes place outside. Although it affects the division of surplus, the overall surplus is unchanged.

If the seller's outside option value is so high that the surplus retained by the buyer can not compensate the buyer's investment cost, the seller's incentive to invest outside may even drive the buyer out of the inside relation. Proposition 3 captures this intuition.

Proposition 3: (O_S, N_B) is equilibrium if and only if $\text{Max}\{\frac{1}{2}\phi, \phi - (1 + [2k]^-)2C\} \leq \psi$.

Proof: see Appendix B.

Graph 4.2 depicts the (O_S, N_B) equilibrium in a $\phi - \psi$ space.

Given $k > -\frac{1}{2}$ and $r > 0$, equilibrium (O_S, N_B) can exist for any value of k and r .

Relation-breaking may always be a potential outcome no matter what level the synergy is between the seller's inside and outside relation, and no matter what degree of complementarities or substitutability is between the buyer and the seller's investment.

For any value of k and r , equilibrium (O_S, N_B) can exist at any value of ϕ . No matter how productive the inside relation is, if the value of the seller's outside option is sufficiently large, relation-breaking will be an equilibrium outcome.

In this equilibrium, the buyer does not invest and seller invests in his outside relation. Ex-post, trade takes place outside. The seller's investment is not useless from social point of view.

Given the seller invests outside, the buyer can invest in the inside relation so as to maintain the inside relation, since by assumption $\phi > \psi$ and ex-post trade will take place inside if the buyer invests. The reason that the buyer does not do so is two-folds. First, the buyer has to assume all investment cost, while share the surplus with the seller. If the marginal return ϕ is not high enough, it is not worth for him to invest. And this is what the hold-up problem is about.

If $\phi \geq 2C$ when $r \geq 1$, or $\phi \geq \frac{2C}{r}$ when $r < 1$, the hold-up problem per se will not be the reason for the buyer's under-investment. But from Proposition 3, (O_S, N_B) can be equilibrium outcome for any value of ϕ . What makes the buyer to under-invest is exactly the seller's investment in the outside option. Given that the seller invests outside, the buyer realizes that his bargaining power has been weakened. And how much it is weakened depends on the seller's outside-option value. If under the resulting sharing rule, the buyer can not make up his cost, he will withdraw his investment. The condition for the buyer's under-invest is $\frac{1}{2}\phi - \frac{1}{2}\psi - C < 0$. $\frac{1}{2}\phi$ is the surplus the buyer can get with $\frac{1}{2}$ bargaining power; $\frac{1}{2}\psi$ is the buyer's losses due to his weakened bargaining power.

Given that the buyer does not invest, the seller may invest inside rather than outside, since the productivity is higher in the inside relation. In equilibrium (O_S, N_B) , the seller does not do so because he has to share surplus with the buyer while incur all the cost, and his share of surplus in the inside relation is less than what he can get outside. The condition for this is $\frac{1}{2}\phi - C \leq \psi - C$, simplifying which yields $\frac{1}{2}\phi \leq \psi$.

The seller may also invest in both given that the buyer under-invests. The rationale is that by investing in both, he can capture the supreme efficiency of the inside relation and at the same time prevent the buyer from free riding on his investment. The drawback of this approach is that it may be too costly. Given investment pair (O_S, N_B) , the gain for the seller to switch to IO_S is $\frac{1}{2}\phi - \frac{1}{2}\psi$, and the loss is $C + 2kC$. If k is non-negative, seller will stick to O_S as long as the buyer sticks to N_B . If k is negative, it may be easier for him to switch rather than for the buyer to do so. The condition necessary to sustain (O_S, N_B) as an equilibrium is $\frac{1}{2}\phi - \frac{1}{2}\psi - (1 + 2k)C \leq 0$, simplifying which yields $\phi - 2(1 + 2k)C \leq \psi$.

Remark 1: *The synergy between the seller's inside and outside relation can help sustain their inside relation.*

From *Proposition 3*, k only affects equilibrium (O_S, N_B) when it is negative. And when k gets more negative, the necessary and sufficient condition for (O_S, N_B) to be equilibrium becomes more stringent. The idea is that when the synergy between the seller's inside and outside relation gets higher (a more negative k), it becomes less costly for the seller to further invest in the inside relation. Since the inside relation is more productive than the outside one ($\phi > \psi$), the seller will not give up this superior surplus and trade will take place between the buyer and the seller. Therefore, synergy helps sustain the inside relation.

Proposition 4: *(IO_S, I_B) is equilibrium if and only one of the following sets of conditions is satisfied:*

- $k \geq 0$, $\phi \geq \frac{2(1 + 2k)C}{r}$ and $\psi \geq (2 + 4k)C$.

- $-\frac{1}{4} \leq k < 0$, $\phi \geq \frac{2}{r}C$ and $\psi \geq (2 + 4k)C$
- $-\frac{1}{2} < k < -\frac{1}{4}$, $\phi \geq \frac{2}{r}C$

Proof: see Appendix B.

Graph 4.1 depicts the (IO_S, I_B) equilibrium in a $\phi - \psi$ space.

Equilibrium (IO_S, I_B) can exist for any value of k and r , given $k > -\frac{1}{2}$ and $r > 0$. For any k and r , (IO_S, I_B) is an equilibrium outcome only if ϕ exceeds $\frac{2}{r}C$, since otherwise, the buyer will be better off if he does not invest ex-ante. When k is positive, the necessary condition on ϕ is more stringent: ϕ has to be above $\frac{2(1+2k)C}{r}$ for the equilibrium to exist.

When $k \geq 0$, the seller's cost function is convex. And as k goes up, it becomes more and more costly for the seller to invest in both relations. Given that the buyer invests, the seller can withdraw his inside investment and free ride on the buyer's one, unless the productivity in the inside relation exceeds the above lower bound. It is apparent that this lower bound is increasing in k .

ψ also has to be above certain lower bound for the equilibrium to exist. ψ can be understood as the increment of the seller's bargaining power. Unless the value of bargaining power exceeds the cost of acquiring it, the seller will not invest outside. k represents the cost of acquiring bargaining power. Apparently, the lower bound for ψ is generally increasing in k .

Note that the seller's investment in his outside relation does not affect the buyer's investment incentive. Although it helps seller to extract a constant amount $(\frac{1}{2}\psi)$ of surplus from buyer, it does not affect the division of surplus on the margin.

In this equilibrium, both the buyer and the seller invest in the inside relation, and the seller also invests in his outside relation. Ex-post, trade takes place inside. The seller's outside investment is useless in the sense that the outside surplus will not be realized afterwards. As (O_S, I_B) , equilibrium (IO_S, I_B) has a flavour of costly bargaining because a trading party makes investment which is not productive at all from social point of view and aims just at extracting surplus.

Proposition 5: Equilibrium (I_S, I_B) exists only if $k > -\frac{1}{4}$. For k satisfies this condition,

(I_S, I_B) is equilibrium if and only if $C < \psi \leq (2 + 4k)C$ and $\phi \geq \text{Max}\{\frac{2C}{r}, \frac{1}{r}\psi\}$.

Proof: see Appendix B.

Graph 4.1 depicts the (I_S, I_B) equilibrium in a $\phi - \psi$ space.

In equilibrium (I_S, I_B) , both the buyer and the seller invest and only invest in the inside relation, which is the social first best of this game. It is first best because after taking into account the ex-ante investment cost, the overall surplus realized ex-post is the highest under this investment pair.

Previous works on Hold-up do not consider the possibility of investing in outside option. If we translate this restriction into our setup, then the seller has exactly the same investment strategies as buyer does, N_S and I_S . In this case, the necessary and sufficient condition for the first best outcome (I_S, I_B) to be equilibrium is $\phi \geq \frac{2C}{r}$.

However, if we allow the seller to invest outside, $\phi \geq \frac{2C}{r}$ is no longer the sufficient condition. For (I_S, I_B) to be an equilibrium, the synergy between the seller's inside and outside relation must be somewhat less than perfect ($k > -\frac{1}{4}$). If not, given choice pair (I_S, I_B) , the seller will definitely further invest outside, no matter how low the efficiency of his outside relation is. The reason is that building bargaining power is not as costly as before after he has invested in the inside relation.

The equilibrium exists only if $\phi \geq \frac{2C}{r}$ and $\phi \geq \frac{1}{r}\psi$. The first one is the standard hold-up free condition. Given that the other party invests, a party will invest only if his share of the marginal return from his investment exceeds his investment cost. The second inequality is about the seller's incentive. Given that the buyer invests, the seller can choose to augment the surplus in the inside relation, or build his bargaining power for ex-post negotiation. And he will do what benefits himself most. Given that the buyer invests, his marginal return from his inside investment is $\frac{1}{2}r\phi$, and that from his outside

investment is $\frac{1}{2}\psi$. For (I_S, I_B) to be equilibrium, it must be that case that $\frac{1}{2}r\phi \geq \frac{1}{2}\psi$.

This boils down to the second inequality.

(I_S, I_B) is equilibrium only if the seller's outside option value is below a lower bound. Given choice pair (I_S, I_B) , what prevents the seller from building bargaining power is just the cost of doing so (note that the buyer's incentive is not affected here, since on the margin, the buyer's share of return is unaffected). If building bargaining power is so efficient (large ψ) that the benefits overwhelm costs, the seller will deviate to choose IO_S . The upper bound for ψ is $(2+4k)C$. Apparently, it is increasing in k . A large k helps sustain (I_S, I_B) as equilibrium. Put differently, given a larger k and all else the same, the set of (ϕ, ψ) where (I_S, I_B) is equilibrium is larger. But we can not claim larger k improves welfare, since it also opens up more scope for (O_S, I_B) to be equilibrium.

Note that this game may have multiple equilibria. We can see this with *Proposition 3* and *Proposition 4*. Given $k > -\frac{1}{2}$ and $r > 0$, equilibrium (O_S, N_B) and equilibrium (IO_S, I_B) can exist for any value of k and r . For any such k and r , (O_S, N_B) is an equilibrium if and only if ψ is sufficiently large, and (IO_S, I_B) is an equilibrium if and only if both ϕ and ψ are sufficiently large. Therefore, given $k > -\frac{1}{2}$ and $r > 0$, for any k and r , (O_S, N_B) and (IO_S, I_B) are both equilibria if and only if both ϕ and ψ are sufficiently large. To be precise, we provide the following corollary which is immediate with *Proposition 3* and *Proposition 4*.

Corollary 3: (O_S, N_B) and (IO_S, I_B) are both equilibria if and only if $\phi \geq \text{Max}\{\frac{2(1+2k)C}{r}, \frac{2C}{r}\}$ and $\psi \geq \text{Max}\{\frac{1}{2}\phi, \phi - (1+[2k]^-)2C, (2+4k)C\}$.

When (O_S, N_B) and (IO_S, I_B) are both equilibria, knowing that the seller will definitely invest outside, the buyer can improve his ex-ante payoff by investing in the inside relationship. Doing so per se is not immediately beneficial since the seller will

accumulate bargaining power large enough to leave him a negative ex-ante payoff. However, knowing that the buyer will invest, the seller will further invest in the inside relation so as to capture its supreme efficiency. And the buyer can share the increment of the inside surplus from the seller's investment and make up his ex-ante investment cost. In this way, both players achieve higher ex-ante payoffs.

Overall, when the seller is allowed to separately invest in his outside option, the hold-up problem gets more severe. Unproductive investments may be made just to accumulate bargaining power (equilibrium (IO_S, I_B)); these inefficient investments may crowd out relationship specific investments (equilibrium (O_S, I_B)); even worse, the buyer-seller relationship may break because of them (equilibrium (O_S, N_B)). All these inefficient outcomes can happen where in the previous formalization of hold-up, socially efficient outcome is an equilibrium outcome. In what follows, we examine whether exclusive contracts can improve efficiency in our scenario.

4.2.1 Exclusive contracts

Assume that the court can verify whom the seller trades with. If so, ex-ante the buyer and the seller can enter into an exclusive contract which stipulates that the seller can only supply to the buyer. Assume that this contract is ex-post renegotiable.⁷⁰ Assume that the buyer and the seller sign this contract ex-ante. As before, we analyze the game with backward induction.

Ex-post, given any investment choice pair, the seller's outside option can no longer be a threat to the buyer. In the case they can not reach agreement, the buyer can insist on the initial contract and prevent the seller from trading outside. Therefore, the seller's disagreement payoff in any cases is θ . His outside option can no longer improve his bargaining position.

However, the seller's outside option is not always useless. When the overall surplus of the outside relation is above that of the inside one, the buyer and the seller will not give up the outside surplus and the initial contract will be renegotiated. Given our assumption $\phi > \psi$, this happens only under choice pair (O_S, N_B) . In this case, the inside surplus is θ , and the outside one is ψ . Obviously, the initial contract will be torn apart:

⁷⁰ If the contract is not renegotiable, the analysis will be simple: the seller's payoff is never sensitive to his investment in the outside option, and therefore he has no incentive to invest outside.

the two parties will bargain over the surplus ψ and the seller ends up trading outside. Under any other choice pairs, renegotiation will not happen and the two party bargaining over the inside surplus each with disagreement payoff 0.

Proposition 6: Under an initial exclusive contract, the equilibrium bargaining outcomes given each pair of investment choices are as follows:

- (N_S, N_B) : Trade does not occur. The gross expected payoffs to the seller and the buyer are $(0, 0)$.
- (N_S, I_B) : The buyer and the seller trade. The gross expected payoffs are $(\frac{\phi}{2}, \frac{\phi}{2})$.
- (O_S, N_B) : The seller trades outside. The payoffs are $(\frac{\psi}{2}, \frac{\psi}{2})$.
- (O_S, I_B) : The buyer and the seller trade. The gross expected payoffs are $(\frac{\phi}{2}, \frac{\phi}{2})$.
- (I_S, N_B) : The buyer and the seller trade. The gross expected payoffs are $(\frac{\phi}{2}, \frac{\phi}{2})$.
- (I_S, I_B) : The buyer and the seller trade. The gross expected payoffs are $(\frac{1+r}{2}\phi, \frac{1+r}{2}\phi)$.
- (IO_S, N_B) : The buyer and the seller trade. The gross expected payoffs are $(\frac{\phi}{2}, \frac{\phi}{2})$.
- (IO_S, I_B) : The buyer and the seller trade. The gross expected payoffs are $(\frac{1+r}{2}\phi, \frac{1+r}{2}\phi)$.

Proof: Except under choice pair (O_S, N_B) , the inside surplus is no less than the outside surplus. In these cases, no renegotiation happens, and the two parties will bargain over the inside surplus. Since both parties' disagreement payoffs are 0, they will share the inside surplus equally.

Under choice pair (O_S, N_B) , since the outside surplus, ψ , is greater than the inside surplus, 0, the initial contract will be renegotiated. The seller will be allowed to trade

outside and they bargain over the surplus ψ . Again, since both parties' disagreement payoffs are 0, they each obtain half of the surplus, $\frac{\psi}{2}$.

QED.

Based on the ex-post payoffs, we can analyze the ex-ante investment choice problem by taking into account the ex-ante investment costs. This gives rise to the following payoff matrix:

		Buyer	
		I_B	N_B
Seller	N_S	$\frac{1}{2}\phi - C$ $\frac{1}{2}\phi$	0 0
	O_S	$\frac{\phi}{2} - C$ $\frac{\phi}{2} - C$	$\frac{\psi}{2}$ $\frac{\psi}{2} - C$
	I_S	$\frac{1+r}{2}\phi - C$ $\frac{1+r}{2}\phi - C$	$\frac{1}{2}\phi$ $\frac{1}{2}\phi - C$
	IO_S	$\frac{1+r}{2}\phi - C$ $\frac{1+r}{2}\phi - 2(1+k)C$	$\frac{1}{2}\phi$ $\frac{1}{2}\phi - 2(1+k)C$

We can see that O_S and IO_S are the dominated choices for the seller, and are dominated by I_S . The idea is that holding the exclusive-rights, the buyer can undo the seller's effort of accumulating bargaining power when trade takes place inside, and has the rights to share the seller's surplus when trade takes place outside. Put in another way, the seller's outside investment will be either useless or be expropriated by the buyer. So as long as $\phi > \psi$, the seller would rather work on the inside relation.

An exclusive contract effectively transforms the game back into the case where the seller can not separately invest in his outside option: his choice set is left with N_S and I_S . The following result is immediate.

Proposition 7: *When the inside relationship is sufficiently productive, $\phi \geq \text{Max}\{2C, \frac{2C}{r}\}$, exclusive contracts help improve efficiency.*

Proof: Exclusivity effectively eliminates O_S and IO_S from the seller's choice set. In the game where the seller can only choose N_S and I_S , the socially optimal outcome (I_S, I_B) is the unique equilibrium outcome if and only if $\phi \geq \text{Max}\{2C, \frac{2C}{r}\}$.

On the other hand, absent an exclusive contract, equilibrium (O_S, I_B) , (O_S, N_B) and (IO_S, I_B) can arise when $\phi \geq \text{Max}\{2C, \frac{2C}{r}\}$ (see Proposition 2, 3, and 4). Therefore, given $\phi \geq \text{Max}\{2C, \frac{2C}{r}\}$, exclusive contracts can not worsen efficiency, but may improve it.

QED.

The intuition is that when accumulating bargaining strength is no longer a feasible option, the seller will concentrate his investment in the inside relation. The buyer is protected by the exclusive contract. He will not be threatened by the seller's outside option, and will be more willing to invest. With exclusivity, the inefficiency induced by the seller's outside option disappears. When hold-up itself is not a problem ($\phi \geq \text{Max}\{2C, \frac{2C}{r}\}$), social optimal is achieved.

Proposition 8: *When the inside relationship is sufficiently unproductive, $\phi \leq \text{Min}\{2C, \frac{2C}{r}\}$, exclusive contracts worsen efficiency.⁷¹*

Proof: Under exclusivity, when $\phi \leq \text{Min}\{2C, \frac{2C}{r}\}$, the unique equilibrium outcome is (N_S, N_B) . Absent exclusivity, the unique equilibrium outcome is (O_S, N_B) .⁷²

⁷¹ Since we have assumed $r\phi > C$, this proposition applies when $r \geq 0.5$

⁷² Appendix B characterizes the equilibrium conditions for choice pair (I_S, N_B) , (IO_S, N_B) , (N_S, I_B) , and (N_S, N_B) . When $\phi \leq \text{Min}\{2C, \frac{2C}{r}\}$, none of these choice pairs can be equilibrium. From Proposition 2, 4, 5, we can see that none of (O_S, I_B) , (IO_S, I_B) , and (I_S, I_B) can be equilibrium

The overall social surplus of equilibrium (N_S, N_B) is 0, while that of (O_S, N_B) is $\psi - C$ which is above 0. Therefore, exclusivity worsens efficiency.

Q.E.D

Investing in outside option is bad when the inside relation is sufficiently productive; it is good when the inside relation is sufficiently unproductive. In the later case, hold-up is severe and the parties will make no relation specific investments. Investing in outside option at least creates some positive surplus. An exclusive contract unselectedly wipes out the effect of outside option. It improves efficiency in the former case, but worsens efficiency in the later one.

Overall, exclusive contracts matter for investment incentives in our setup. The presence of exclusivity sufficiently reduces the sensitivity of the seller's payoff to his investment in the outside option. As long as his investment in the outside option is less productive than his relationship specific investment, his incentive to invest outside will be wiped out. Our finding does not contradict the *Irrelevance result* in Segal and Whinston (2000a) since the seller's investment in our setup can be purely external. Exclusivity improves efficiency when the inside relationship is sufficiently productive, but worsens it when the inside relationship is sufficiently unproductive.

Note that so far we have only studied the equilibrium outcomes of the “no contracts” sub-game and the “exclusive contract” sub-game. We have not addressed the issue of how the players might agree to an exclusive contract as part of the game. To address this issue, suppose that a contracting stage exists before the investment stage. At the contracting stage, the players bargain over whether to place their relationship under an exclusive contract. Our prior expectation is that if the players are allowed to make side payment and are not wealth-constrained, the bargaining outcome at the contracting stage

when $\phi \leq \text{Min}\{2C, \frac{2C}{r}\}$. Therefore, the only possible equilibrium for $\phi \leq \text{Min}\{2C, \frac{2C}{r}\}$ is (O_S, N_B) .

From *proposition 3*, the condition for (O_S, N_B) to be equilibrium places no restriction on ϕ . The

condition for ψ is $\text{Max}\{\frac{1}{2}\phi, \phi - (1 + [2k]^-)2C\} \leq \psi$. When $\phi \leq \text{Min}\{2C, \frac{2C}{r}\}$, the condition for ψ is definitely satisfied. Therefore, the unique equilibrium outcome is (O_S, N_B) .

will be efficient, in which case their transaction will be placed in the relatively more efficient governing mode. However, this issue has to be subject to further investigation.

4.3 Conclusion

In the previous formalizations of the hold-up problem, e.g. Grossman and Hart (1986), transaction parties are not allowed to separately invest in their outside options, and the values of their outside options are merely a by-product of the parties' relationship specific investments. Since a party's outside option provides bargaining strength during ex-post negotiation, the party has extra incentives to make relationship specific investments and the existence of outside option partially offsets the underinvestment problem induced by hold-up.

This thesis shows that this type of formulations underestimates the hold-up problem. After considering the possibility of separately investing in outside option, we show that outside option can actually be a source of non-cooperative and inefficient behaviours and the hold-up problem is potentially more severe than previously observed. Unproductive investments may be made just to accumulate bargaining power. These inefficient investments may crowd out relationship specific investments; even worse, the socially efficient relationship may break because of them. All these inefficient outcomes can happen where in the previous formalization of hold-up, socially efficient outcome is the unique equilibrium outcome.

Based on our set-up, we find that exclusive contracts can affect investment incentive. The presence of exclusivity sufficiently reduces the sensitivity of a party's payoff to his investment in his outside option. As long as his investment in the outside option is less productive than his relationship specific investment, his incentive to invest outside will be wiped out. We also find that exclusivity improves efficiency when relationship specific investments are sufficiently productive, but worsens it when they are sufficiently unproductive.

Table 3.1 Descriptive Statistics for Firm Characteristics

Offering Type	Open Offers		T Test for Difference in		P-Value
	Number of Observation		Mean	Median	
Shares issued /Old shares plus New shares	100				
Gross Proceeds (£1,000,000)		24.74%	20.00%		0.82
Gross Proceeds/Market value		18	10		-1.14
Issue Discounts		33.60%	25.12%		1.61
Market Value (£1,000,000)		16%	9.5%		-1.17
Offer Price (£1)		125	38		-1.11
		2.2	0.75		-1.89
					0.03
Offering Type	Right Issues				
	Number of Observation		Mean	Median	
Shares issued /Old shares plus New shares	29				
Gross Proceeds (£1,000,000)		22.55%	20.00%		
Gross Proceeds/Market value		156	22		
Issue Discounts		25.04%	19.50%		
Market Value (£1,000,000)		20%	19%		
Offer Price (£1)		934	130		
		4.2	2.8		

A difference-in-means *t*-test is conducted to compare the average firm characteristics between the open offer stocks and the rights offer stocks.

The *t* statistics is computed as
$$\frac{\mu_{Open} - \mu_{Rights}}{\sqrt{\frac{VAR_{Open}}{N_{Open}} + \frac{VAR_{Rights}}{N_{Rights}}}}$$

Table 3.2 Summary statistics for Spread

Difference-in-means *t*-tests, paired difference *t* tests and binomial *Z* tests are conducted to compare the spread between the pre-offer period and the post-offer period, and between the open offer stocks and rights offer stocks in the same event period.

Spread measure	Number of Stocks	Mean pre-offer		Mean post-offer		Average Change in spread		Difference in mean <i>t</i> test		Binomial statistics	Mean log(s2/s1)	Paired difference <i>t</i> -test
		proportional spread	proportional spread	proportional spread	proportional spread	spread	spread	in mean <i>t</i> test	% > 0			
Open offers												
	volume (%) effective spread	100	6.78	6.45	-0.3			-0.416	0.560	1.200	-0.022	-0.04
	(%) effective spread	100	6.55	6.58	0			0.044	0.530	0.600	0.016	0.04
	time (%) quoted spread	100	7.24	7.61	0.4			0.395	0.620	2.400	0.063	0.17
Rights offers	(%) quoted spread	100	7.55	7.79	0.2			0.242	0.590	1.800	0.055	0.16
	volume (%) effective spread	29	4.28	4.34	0.1			0.043	0.517	0.186	0.050	0.09
	(%) effective spread	29	4.29	4.15	-0.1			-0.109	0.448	-0.557	-0.002	-0.00
	time (%) quoted spread	29	4.79	4.8	0			0.007	0.586	0.928	0.049	0.19
Open offers vs. Rights offers	(%) quoted spread	29	4.83	4.97	0.1			0.089	0.552	0.557	0.046	0.23

Open offers vs. Rights offers

Pre-offer Difference in mean *t* test

Post-offer Difference in mean *t* test

Mean(Open offer) – Mean(Rights offer)

volume (%) effective spread
(%) effective spread
time (%) quoted spread
(%) quoted spread

2.13
1.99
2.02
2.15

1.93
2.33
2.49
2.24

Paired difference *t* statistics is calculated as, $t = \frac{Average(Spread^{Post} - Spread^{Pre})}{SE}$. SE is the standard deviation of the matched spread changes divided by the square root of the number of sample observations.

Table 3.3 Summary statistics for Trading characteristics.

Average Price Level (£1)		Pre offer	Post offer
Open offers		2.27	2.32
Rights offers		4.82	4.86
Difference in mean (T ratio, p value)		-2.39 (0.01)	-1.99 (0.03)
Average trades per day			
Open offers		30.77	33.72
Rights offers		19.77	19.34
Difference in mean (T ratio, p value)		1.21 (0.12)	1.27 (0.1)
Average shares traded per day			
Open offers		257357	381401
Rights offers		289764	179321
Difference in mean (T ratio, p value)		-0.19 (0.43)	1.20 (0.12)
Average pound Volume per day (£1,000)			
Open offers		256	273
Rights offers		402	547
Difference in mean (T ratio, p value)		-0.97 (0.17)	-1.18 (0.12)
Average Volatility			
Open offers		0.21	0.21
Rights offers		0.27	0.43
Difference in mean (T ratio, p value)		-0.79 (0.22)	-1.07 (0.15)

Table 3.4 Summary statistics for changes in trading characteristics

	Changes in average mid point	Change in the number of trades per day	Changes in the number of shares traded per day	Changes in pound Volume	Changes in mid-point variation
Open Offers					
Mean log change [$\text{Log}(\text{Post} / \text{Pre})$]	-0.045	0.164	0.331	0.286	-0.811
Paired difference t test	-0.154	0.209	0.306	0.249	-0.184
Percentage of stocks with increases	0.430	0.540	0.570	0.560	0.410
Binomial Z test	-1.400	0.800	1.400	1.200	-1.800
Rights offers					
Mean log change [$\text{Log}(\text{Post} / \text{Pre})$]	-0.076	-0.059	0.213	0.131	0.009
Paired difference t test	-0.369	-0.081	0.209	0.126	0.008
Percentage of stocks with increases	0.241	0.483	0.517	0.483	0.448
Binomial Z test	-2.785	-0.186	0.186	-0.186	-0.557
Difference in mean test					
T statistics	0.655	1.421	0.541	0.693	-1.695

Table 3.5 Regression results for specification (a) and (b):

$Spread(\%) = \beta_0 + \beta_1 \ln(Firm\ size) + \beta_2 \frac{1}{Price} + \beta_3 \ln(Trading\ Volume) + \beta_4 \ln(Volatility) + \beta_5 D_P + \beta_6 D_R + \beta_7 D_{PR}$ (a)

$Spread(\%) = \beta_0 + \beta_1 \ln(Firm\ size) + \beta_2 \frac{1}{Price} + \beta_3 \ln(Trading\ Volume) + \beta_5 D_P + \beta_6 D_R + \beta_7 D_{PR}$ (b)

Dependent Variable	Volume Weighted Effective			Time Weighted Quoted		
Specification:	Spread	(a)	(b)	Simple Effective Spread	Spread	Simple Quoted Spread
Independent variables:						
Constant	0.31	8.64	0.3	0.28	0.31	0.32
Log of Market Capitalization	T statistics	-0.0039	-0.0039	-0.0027	-0.0027	-0.0029
		-2.28	-2.19	-1.97	-1.87	-1.75
1/Price	T statistics	0.23	0.23	0.29	0.33	0.35
Log of Pound Volume per day	T statistics	-0.01	-0.01	-0.01	-0.01	-0.01
		-5.87	-6	-6.01	-6.14	-6.39
Log of Mid quote variation	T statistics	0.00087	0.00087	0.00103	0.00123	0.00125
		1.18	1.18	1.65	1.99	2.01
Dummy for Post	T statistics	0.0008	-0.0001	0.0041	0.0079	0.0066
Dummy for Right offer	T statistics	-0.0096	-0.0096	-0.0076	-0.0073	-0.0089
		-1.19	-1.18	-0.9	-0.89	-0.92
Interactive Dummy for Post and Right	T statistics	0.0007	0.0016	-0.0051	-0.0074	-0.0051
		0.07	0.14	-0.45	-0.36	-0.49
R square		0.49	0.48	0.53	0.52	0.54
<hr/>						
t test for $\beta_5 + \beta_7 = 0$	T statistics	0.17	0.16	-0.11	0.04	0.14

Table 3.6 Panel A. Regression results for specification (c): $\Delta Spread = \beta_0 + \beta_1 \Delta Firm\ size + \beta_2 \Delta Price + \beta_3 \Delta Volume + \beta_4 \Delta Volatility + \varepsilon$ (c)

Dependent Variable	Changes in Volume weighted effective spread			Changes in effective spread			Changes in Time weighted spread			Changes in quoted spread		
	Open offers	Rights offers		Open offers	Rights offers		Open offers	Rights offers		Open offers	Rights offers	
Constant	0.009	0.037		0.028	-0.023		0.033	0.065		0.032	0.001	
	0.137	0.240	<i>T</i> statistics	0.701	-0.298		0.769	1.217		0.868	0.030	
Changes in market capitalization	-0.059	-0.055		-0.076	-0.037		0.081	-0.121		0.043	0.036	
	-0.419	-0.109	<i>T</i> statistics	-1.001	-0.164		0.862	-0.577		0.630	0.242	
Changes in Price level	-0.441	-0.443		-0.508	-0.497		-0.590	-0.300		-0.600	-0.627	
	-2.789	-0.890	<i>T</i> statistics	-3.828	-1.997		-3.946	-1.168		-4.206	-3.080	
Changes in Pound Volume	-0.094	-0.094		-0.046	-0.081		-0.060	-0.117		-0.054	-0.075	
	-1.374	-0.719	<i>T</i> statistics	-1.709	-1.985		-2.237	-3.177		-2.020	-2.512	
Changes in Mid quote variation	0.009	0.258		0.001	0.045		0.002	-0.019		0.000	-0.014	
	1.344	2.850	<i>T</i> statistics	0.268	0.725		0.663	-0.503		0.092	-0.407	
R square	0.150	0.340		0.332	0.325		0.275	0.453		0.361	0.540	

Table 3.6 Panel B. Regression results for specification (d): $\Delta Spread = \beta_0 + \beta_1 \Delta Firm\ size + \beta_2 \Delta Price + \beta_3 \Delta Volume + \varepsilon$ (d)

Dependent Variable	Changes in Volume weighted effective spread			Changes in effective spread			Changes in Time weighted quoted spread			Changes in quoted spread		
	Open offers	Rights offers		Open offers	Rights offers		Open offers	Rights offers		Open offers	Rights offers	
Constant	0.004	0.077	0.5015	0.027	-0.016	0.032	0.032	0.062	1.146	0.032	-0.001	-0.028
	0.056			0.697	-0.215	0.750				0.876		
Changes in market capitalization	-0.074	-0.474	-1.082	-0.078	-0.110	0.077	0.077	-0.089	-0.432	0.043	0.060	0.415
	-0.563			-1.034	-0.554	0.836				0.629		
Changes in Price level	-0.434	-0.780	-1.219	-0.507	-0.556	-0.588	-0.588	-0.275	-1.106	-0.600	-0.608	-3.225
	-2.728			-3.804	-2.118	-3.924				-4.186		
Changes in Pound Volume	-0.086	0.033	0.288	-0.045	-0.059	-0.058	-0.058	-0.127	-3.466	-0.054	-0.082	-2.802
	-1.340			-1.742	-1.583	-2.250				-2.084		
R square	0.145	0.198	0.331	0.308	0.274	0.449	0.361	0.537				

Table 3.7 Statistics for MRR estimations.

	Mean	Mean S.E.	S.D	Median	%insignificant	% negative
Open Offers (73 offers)						
PRE						
Adverse selection Component (0.01£)	0.4893	1.6852	2.1043	0.0865	91.67%	34.72%
Temporary Component (0.01£)	2.7712	1.3173	4.9653	1.1980	38.89%	0.00%
Adverse selection Component (% of price)	0.24%	1.04%	0.78%	0.18%		
Temporary Component (% of price)	2.24%	0.82%	2.18%	1.45%		
% of spread attributed to adverse selection	4.68%		91.88%	9.34%		
Implied spread (0.01£)	6.52		11.89	3.20		
Implied spread (% of Price)	4.97%		4.56%	3.52%		
POST						
Adverse selection Component (0.01£)	1.3356	1.9540	4.6295	0.1186	100.00%	29.17%
Temporary Component (0.01£)	2.7440	1.5264	4.7180	1.3550	36.11%	0.00%
Adverse selection Component (% of price)	0.28%	1.00%	0.78%	0.26%		
Temporary Component (% of price)	2.34%	0.80%	2.32%	1.64%		
% of spread attributed to adverse selection	246.14%		2025.5%	16.64%		
Implied spread (0.01£)	8.16		17.8	2.65		
Implied spread (% of Price)	5.24%		5.07%	3.64%		
Group mean test of difference between PRE and POST						
<i>T statistics</i>						
Adverse selection component (0.01£)	-0.12945					
Adverse selection component (%)	-0.37					

Right Offers (27 offers)						
PRE						
	<i>Mean</i>	Mean S.E.	S.D	<i>Median</i>	%insignificant	%negative
Adverse selection Component (0.01£)	<i>1.7038</i>	6.7217	8.8875	<i>-0.1021</i>	92.59%	51.85%
Temporary Component (0.01£)	<i>5.8130</i>	5.4886	13.504	<i>2.3175</i>	62.96%	0.00%
Adverse selection Component (% of price)	<i>0.04%</i>	1.18%	0.86%	<i>-0.05%</i>		
Temporary Component (% of price)	<i>1.43%</i>	0.95%	1.66%	<i>0.82%</i>		
% of spread attributed to adverse selection	<i>22.66%</i>		89.1%	<i>7.58%</i>		
Implied spread (0.01£)	<i>15.03</i>		43.53	<i>4.07</i>		
Implied spread (% of Price)	<i>2.94%</i>		3.32%	<i>2.28%</i>		
POST						
Adverse selection Component (0.01£)	<i>0.8910</i>	5.6793	3.5351	<i>-0.0227</i>	100.00%	51.85%
Temporary Component (0.01£)	<i>4.6381</i>	4.3434	7.5556	<i>2.3636</i>	62.96%	0.00%
Adverse selection Component (% of price)	<i>0.10%</i>	1.29%	0.95%	<i>-0.01%</i>		
Temporary Component (% of price)	<i>1.52%</i>	1.01%	2.03%	<i>0.85%</i>		
% of spread attributed to adverse selection	<i>103.60%</i>		305.64%	<i>28.38%</i>		
Implied spread (0.01£)	<i>11.06</i>		17.45	<i>5.02</i>		
Implied spread (% of Price)	<i>3.24%</i>		4.16%	<i>2.39%</i>		
Group mean test of reduction from PRE to POST						
	<i>T statistics</i>					
Adverse selection component (0.01£)		0.11				
Adverse selection component (%)		-0.08				

Table 3.8 Statistics for refined MRR estimations.

Open Offers (25 offers)		Mean	S.E.	S.D	Median	%insignificant	%negative
PRE							
Adverse selection Component (0.01£)		1.0738	1.5557	2.4485	0.2658	76.00%	12.00%
Temporary Component (0.01£)		4.9032	1.2295	7.6271	1.7616	12.00%	0.00%
Adverse selection Component (% of price)		0.26%	0.30%	0.26%	0.19%		
Temporary Component (% of price)		1.60%	0.24%	1.19%	1.05%		
% of spread attributed to adverse selection		16.20%		17.24%	11.09%		
Implied spread (0.01£)		11.95		18.56	4.59		
Implied spread (% of Price)		3.73%		2.34%	3.20%		
POST							
Adverse selection Component (0.01£)		3.0428	2.5330	7.0278	0.3406	100.00%	12.00%
Temporary Component (0.01£)		5.1718	1.9590	7.2934	1.6904	16.00%	0.00%
Adverse selection Component (% of price)		0.33%	0.42%	0.44%	0.25%		
Temporary Component (% of price)		1.70%	0.33%	1.16%	1.35%		
% of spread attributed to adverse selection		17.68%		23.63%	14.23%		
Implied spread (0.01£)		16.43		27.50	4.97		
Implied spread (% of Price)		4.05%		2.25%	3.52%		
Group mean test of reduction from PRE to POST		<i>T statistics</i>					
Adverse selection component (0.01£)		-0.32					
Adverse selection component (%)		-0.34					

Right Offers (10 offers)

PRE

Adverse selection Component (0.01£)
Temporary Component (0.01£)
Adverse selection Component (% of price)
Temporary Component (% of price)
% of spread attributed to adverse selection
Implied spread (0.01£)
Implied spread (% of Price)

<i>Mean</i>	<i>Mean S.E.</i>	<i>S.D</i>	<i>Median</i>	<i>%insignificant</i>	<i>%negative</i>
5.5275	10.8611	13.2171	0.0177	90.00%	40.00%
10.9225	9.1956	21.6683	3.5981	40.00%	0.00%
0.41%	0.77%	0.67%	0.10%		
1.36%	0.64%	1.26%	0.83%		
10.81%		32.99%	4.68%		
32.90		69.19	9.06		
3.55%		3.33%	2.81%		

POST

Adverse selection Component (0.01£)
Temporary Component (0.01£)
Adverse selection Component (% of price)
Temporary Component (% of price)
% of spread attributed to adverse selection
Implied spread (0.01£)
Implied spread (% of Price)

1.4267	8.2821	4.0811	0.0167	100.00%	40.00%
7.9197	6.2502	11.6097	3.3247	40.00%	0.00%
0.24%	0.68%	0.45%	0.06%		
1.26%	0.52%	1.15%	0.96%		
4.27%		33.10%	6.92%		
18.69		25.55	6.80		
3.01%		2.75%	1.93%		

Group mean test of reduction from PRE to

POST

Adverse selection component (0.01£)
Adverse selection component (%)

<i>T statistics</i>	-0.08
	-0.03

Table 3.9 Panel A. Summary statistics for market makers' quotes in OPEN OFFER stocks

Name of the security	Pre					Average number of MM per day					Post					Average number of MM per day				
	NMS	Min quote size	Max quote size	Average quote size	Number of MM	Average number of MM per day	NMS	Min quote size	Max quote size	Average quote size	Number of MM	Average number of MM per day	NMS	Min quote size	Max quote size	Average quote size	Number of MM	Average number of MM per day		
AIH	3000	3250	3250	3250	3	2.3	3000	3250	3250	3250	3	3	3000	3250	3250	3250	3	3		
AZM	3000	3250	5250	4450	5	5	5000	3250	5250	4550	5	5	5000	3250	5250	4550	5	5		
ALM	5000	5250	5250	5250	3	3	5000	5250	5250	5250	3	3	5000	5250	5250	5250	3	3		
ARE	25000	25000	50000	31250	4	4	25000	25000	50000	31250	4	4	25000	25000	50000	31250	4	4		
ATN	3000	3250	10000	5658	5	5	5000	3250	5250	4785	6	5.2	5000	3250	5250	4785	6	5.2		
ESY	1000	1250	2250	1890	5	5	1000	1250	2250	1820	5	5	1000	1250	2250	1820	5	5		
EPF	1000	25000	25000	25000	3	3	1000	25000	25000	25000	4	4	1000	25000	25000	25000	4	4		
ETE	2000	2250	2500	2333	3	3	3000	2250	2500	2333	3	3	3000	2250	2500	2333	3	3		
FUR	1000	1250	1250	1250	4	3.3	1000	1250	1250	1250	4	4	1000	1250	1250	1250	4	4		
ITL	3000	2250	10000	4643	7	7	5000	3250	5250	4921	7	7	5000	3250	5250	4921	7	7		
ITK	3000	10000	10000	10000	5	5	5000	10000	10000	10000	5	5	5000	10000	10000	10000	5	5		
ITX	1000	1250	1250	1250	3	3	2000	1250	1250	1250	4	3.75	2000	1250	1250	1250	4	3.75		
KYS	10000	5000	10000	9200	6	6	15000	10000	15000	10487	6	6	15000	10000	15000	10487	6	6		
LNT	5000	5250	50000	23776	4	4	1000	5250	25000	20063	4	4	1000	5250	25000	20063	4	4		
LNK	10000	10000	10000	10000	7	7	10000	10000	10000	10000	8	7	10000	10000	10000	10000	8	7		
MIN	1000	25000	25000	25000	4	4	1000	25000	25000	25000	4	4	1000	25000	25000	25000	4	4		
NMT	1000	2500	2500	2500	4	4	1000	2500	2500	2500	4	4	1000	2500	2500	2500	4	4		
OGS	5000	3250	5250	5160	10	10	5000	3250	5250	5160	10	10	5000	3250	5250	5160	10	10		
PLM	10000	10000	10000	10000	5	5	10000	10000	10000	10000	5	5	10000	10000	10000	10000	5	5		
PRM	1000	5250	10000	7150	2	2	1000	5250	10000	5250	2	2	1000	5250	5250	5250	2	2		
PRO	25000	25000	25000	25000	7	6.9	25000	25000	25000	25000	7	7	25000	25000	25000	25000	7	7		
RBI	5000	5250	5250	5250	3	3	5000	5250	5250	6144	5	4.25	5000	5250	10000	6144	5	4.25		
RTS	1000	1250	1250	1250	2	2	1000	1250	1250	1250	2	2	1000	1250	1250	1250	2	2		
SWD	1000	1250	2500	2313	4	4	2000	1250	2500	1970	5	4.95	2000	1250	2500	1970	5	4.95		
XEN	5000	5250	5250	5250	5	5	10000	5250	5250	5250	5	5	10000	5250	5250	5250	5	5		

Table 3.9 Panel B. Summary statistics for market makers' quotes in RIGHTS OFFER stocks

Name of the security	Pre NMS	Min quote size	Max quote size	Average Quote size	Number of MM	Average number of MM per day	Post NMS	Min quote size	Max quote size	Average Quote size	Number of MM	Average number of MM per day
BGC	3000	3250	5250	4750	4	4	3000	3250	5250	4750	4	4
EMA	15000						15000					
GRD	2000	3250	3250	3250	4	4	3000	3250	3250	3250	4	4
MSX	50000	100000	100000	100000	4	4	50000	100000	100000	100000	4	4
NSB	1000	2250	2250	2250	3	3	1000	1250	2250	2185.48	4	3.1
OMH	25000	25000	25000	25000	5	4.95	25000	25000	25000	25000	5	5
SRT	1000	1250	2500	1968.75	2	2	1000	1250	1250	1250	2	2
TOX	5000	3250	3250	3250	6	5.15	5000	3250	5250	4850	6	6
WRC	5000	3250	5250	3750	4	4	5000	5250	5250	5250	4	4
WSH	3000	2500	2500	2500	5	5	3000	2500	3000	2950	5	5

Table 3.11 Panel A. Cumulative abnormal returns for OPEN-OFFER STOCKS PRE-OFFER trades.

OPEN OFFER STOCKS PRE OFFER

	-4	-3	-2	-1	0	1	2	3	4	5
Small Purchases	-0.002%	-0.003%	-0.006%	-0.010%	2.059%	-0.026%	-0.033%	-0.041%	-0.040%	-0.046%
T-stat	-0.45	-0.48	-0.70	-1.02	100.50	-1.91	-2.19	-2.43	-2.11	-2.25
Small Sales	-0.001%	-0.003%	-0.007%	-0.007%	-2.062%	-0.007%	-0.004%	0.003%	0.005%	0.004%
T-stat	-0.20	-0.36	-0.58	-0.48	-76.69	-0.35	-0.18	0.11	0.19	0.13
Median Purchases	0.014%	0.032%	0.058%	0.092%	2.078%	0.190%	0.233%	0.261%	0.289%	0.315%
T-stat	2.39	3.50	4.42	5.51	80.79	8.73	9.33	9.56	9.55	9.61
Median Sales	-0.015%	-0.046%	-0.062%	-0.096%	-2.169%	-0.239%	-0.295%	-0.330%	-0.355%	-0.377%
T-stat	-2.41	-4.81	-5.12	-6.39	-80.48	-11.08	-12.09	-12.37	-12.20	-11.60
Large Purchases	0.004%	0.041%	0.046%	0.072%	1.921%	0.315%	0.387%	0.444%	0.485%	0.516%
T-stat	0.48	2.07	1.96	2.62	44.97	8.69	9.64	9.74	9.90	9.79
Large Sales	0.004%	-0.002%	-0.006%	-0.024%	-2.088%	-0.220%	-0.285%	-0.328%	-0.370%	-0.410%
T-stat	0.42	-0.18	-0.33	-1.12	-43.73	-6.47	-7.54	-8.04	-8.40	-8.65
Difference of absolute value of CAR between Median purchases and Median sales						-0.049%	-0.062%	-0.069%	-0.066%	-0.062%
T stat						-1.60	-1.78	-1.82	-1.57	-1.34
Difference of absolute value of CAR between large purchases and larger sales						0.095%	0.102%	0.116%	0.115%	0.105%
T stat						1.91	1.85	1.90	1.75	1.48
Difference between large buy and median buy						0.125%	0.155%	0.184%	0.196%	0.201%
T stat						2.96	3.27	3.46	3.40	3.24
Difference between large sale and median sale						-0.02%	-0.01%	0.00%	0.01%	0.03%
T stat						-0.47	-0.21	-0.04	0.28	0.59

Table 3.11 Panel B. Cumulative abnormal returns for OPEN-OFFER STOCKS Post OFFER trades.

OPEN OFFER STOCKS POST OFFER

	-4	-3	-2	-1	0	1	2	3	4	5
Small Purchases	-0.010%	-0.012%	-0.009%	-0.017%	2.563%	-0.009%	-0.004%	-0.001%	-0.004%	-0.007%
T-stat	-1.53	-1.19	-0.72	-1.08	76.74	-0.45	-0.16	-0.02	-0.13	-0.24
Small Sales	0.002%	0.003%	0.006%	0.002%	-2.303%	0.012%	0.014%	0.012%	0.012%	0.000%
T-stat	0.37	0.26	0.45	0.10	-62.60	0.56	0.59	0.46	0.41	0.00
Median Purchases	0.009%	0.039%	0.053%	0.075%	2.734%	0.172%	0.204%	0.221%	0.237%	0.258%
T-stat	1.23	3.65	3.73	4.17	70.83	6.97	7.33	7.20	7.02	7.01
Median Sales	-0.015%	-0.046%	-0.068%	-0.089%	-2.525%	-0.225%	-0.269%	-0.288%	-0.308%	-0.321%
T-stat	-2.34	-4.57	-5.00	-5.39	-66.08	-9.63	-10.23	-10.00	-9.82	-9.54
Large Purchases	0.019%	0.009%	0.040%	0.067%	2.238%	0.295%	0.356%	0.417%	0.456%	0.485%
T-stat	1.56	0.50	1.65	2.28	37.20	7.05	7.56	7.89	7.98	7.83
Large Sales	-0.009%	-0.017%	-0.030%	-0.044%	-2.285%	-0.252%	-0.310%	-0.331%	-0.355%	-0.388%
T-stat	-0.86	-1.10	-1.50	-1.78	-38.91	-7.56	-8.42	-8.17	-7.84	-7.89
Difference of absolute value of CAR between Median purchases and Median sales						-0.052%	-0.064%	-0.067%	-0.071%	-0.063%
T stat						-1.53	-1.68	-1.59	-1.54	-1.26
Difference of absolute value of CAR between large purchases and larger sales						0.043%	0.046%	0.086%	0.101%	0.097%
T stat						0.81	0.77	1.29	1.39	1.22
Difference between large buy and median buy						0.12%	0.15%	0.20%	0.22%	0.23%
T stat						2.52	2.77	3.20	3.30	3.15
Difference between large sale and median sale						0.03%	0.04%	0.04%	0.05%	0.07%
T stat						0.67	0.91	0.86	0.85	1.13

Table 3.11 Panel C. Cumulative abnormal returns for RIGHTS- OFFER STOCKS Pre OFFER trades.

RIGHTS OFFER STOCKS PRE OFFER

	-4	-3	-2	-1	0	1	2	3	4	5
Small Purchases	0.004%	-0.003%	0.002%	0.004%	1.351%	0.007%	0.008%	-0.018%	-0.017%	-0.002%
T-stat	0.35	-0.16	0.09	0.15	30.35	0.17	0.18	-0.37	-0.31	-0.04
Small Sales	0.018%	0.008%	0.000%	-0.032%	-1.387%	-0.054%	-0.092%	-0.089%	-0.069%	-0.087%
T-stat	1.28	0.33	-0.01	-0.87	-22.97	-1.18	-1.76	-1.53	-1.06	-1.18
Median Purchases	-0.001%	0.026%	0.019%	0.037%	1.525%	0.140%	0.182%	0.210%	0.247%	0.266%
T-stat	-0.09	1.31	0.62	0.99	29.39	2.78	3.19	3.26	3.47	3.46
Median Sales	-0.033%	-0.084%	-0.109%	-0.143%	-1.560%	-0.247%	-0.296%	-0.348%	-0.397%	-0.422%
T-stat	-2.04	-3.08	-3.23	-3.62	-25.49	-4.50	-4.72	-5.00	-5.06	-4.96
Large Purchases	0.005%	0.027%	0.034%	0.028%	1.625%	0.250%	0.322%	0.399%	0.452%	0.517%
T-stat	0.18	0.72	0.71	0.48	17.35	3.24	3.54	3.96	4.02	4.24
Large Sales	-0.002%	0.013%	0.006%	0.006%	-1.643%	-0.153%	-0.175%	-0.250%	-0.276%	-0.298%
T-stat	-0.10	0.42	0.15	0.13	-15.99	-2.06	-2.10	-2.60	-2.67	-2.70
Difference of absolute value of CAR between Median purchases and Median sales					T stat	-0.107%	-0.114%	-0.138%	-0.150%	-0.156%
						-1.44	-1.35	-1.45	-1.42	-1.36
Difference of absolute value of CAR between large purchases and larger sales					T stat	0.097%	0.147%	0.149%	0.176%	0.219%
						0.90	1.19	1.07	1.15	1.33
Difference between large buy and median buy					T stat	0.11%	0.14%	0.19%	0.21%	0.25%
						1.20	1.31	1.58	1.55	1.74
Difference between large sale and median sale					T stat	-0.09%	-0.12%	-0.10%	-0.12%	-0.12%
						-1.01	-1.15	-0.83	-0.93	-0.89

Table 3.11 Panel D. Cumulative abnormal returns for RIGHTS- OFFER STOCKS Post OFFER trades.

RIGHTS OFFER STOCKS POST OFFER	-4	-3	-2	-1	0	1	2	3	4	5
Small Purchases	-0.001%	0.013%	0.012%	0.018%	1.355%	0.006%	0.001%	-0.009%	-0.020%	-0.030%
T-stat	-0.15	1.01	0.72	0.85	35.95	0.20	0.02	-0.26	-0.51	-0.73
Small Sales	-0.010%	-0.020%	-0.020%	-0.027%	-1.285%	-0.025%	-0.041%	-0.051%	-0.053%	-0.077%
T-stat	-1.17	-1.08	-0.83	-0.88	-23.65	-0.60	-0.85	-0.94	-0.90	-1.21
Median Purchases	0.012%	0.025%	0.040%	0.058%	1.540%	0.130%	0.162%	0.177%	0.180%	0.194%
T-stat	1.18	1.54	1.75	2.00	30.74	3.24	3.58	3.54	3.29	3.22
Median Sales	-0.034%	-0.045%	-0.060%	-0.075%	-1.342%	-0.160%	-0.191%	-0.214%	-0.232%	-0.255%
T-stat	-2.27	-1.84	-1.83	-2.00	-22.52	-3.14	-3.36	-3.51	-3.50	-3.48
Large Purchases	0.032%	0.060%	0.084%	0.095%	1.491%	0.239%	0.303%	0.351%	0.375%	0.423%
T-stat	1.96	2.31	2.40	2.30	18.02	3.92	4.34	4.45	4.41	4.62
Large Sales	0.009%	-0.019%	-0.012%	-0.036%	-1.714%	-0.208%	-0.248%	-0.268%	-0.278%	-0.316%
T-stat	0.49	-0.66	-0.27	-0.70	-15.04	-2.98	-3.27	-3.19	-3.06	-3.17
Difference of absolute value of CAR between Median purchases and Median sales						-0.030%	-0.029%	-0.037%	-0.052%	-0.062%
T stat						-0.47	-0.40	-0.47	-0.61	-0.65
Difference of absolute value of CAR between large purchases and larger sales						0.031%	0.056%	0.083%	0.097%	0.108%
T stat						0.34	0.54	0.72	0.78	0.79
Difference between large buy and median buy						0.11%	0.14%	0.17%	0.20%	0.23%
T stat						1.50	1.69	1.86	1.93	2.09
Difference between large sale and median sale						0.05%	0.06%	0.05%	0.05%	0.06%
T stat						0.55	0.60	0.52	0.41	0.49

Table 3.14 Panel 1, Pattern of Human Intermediation, Open-offer stocks

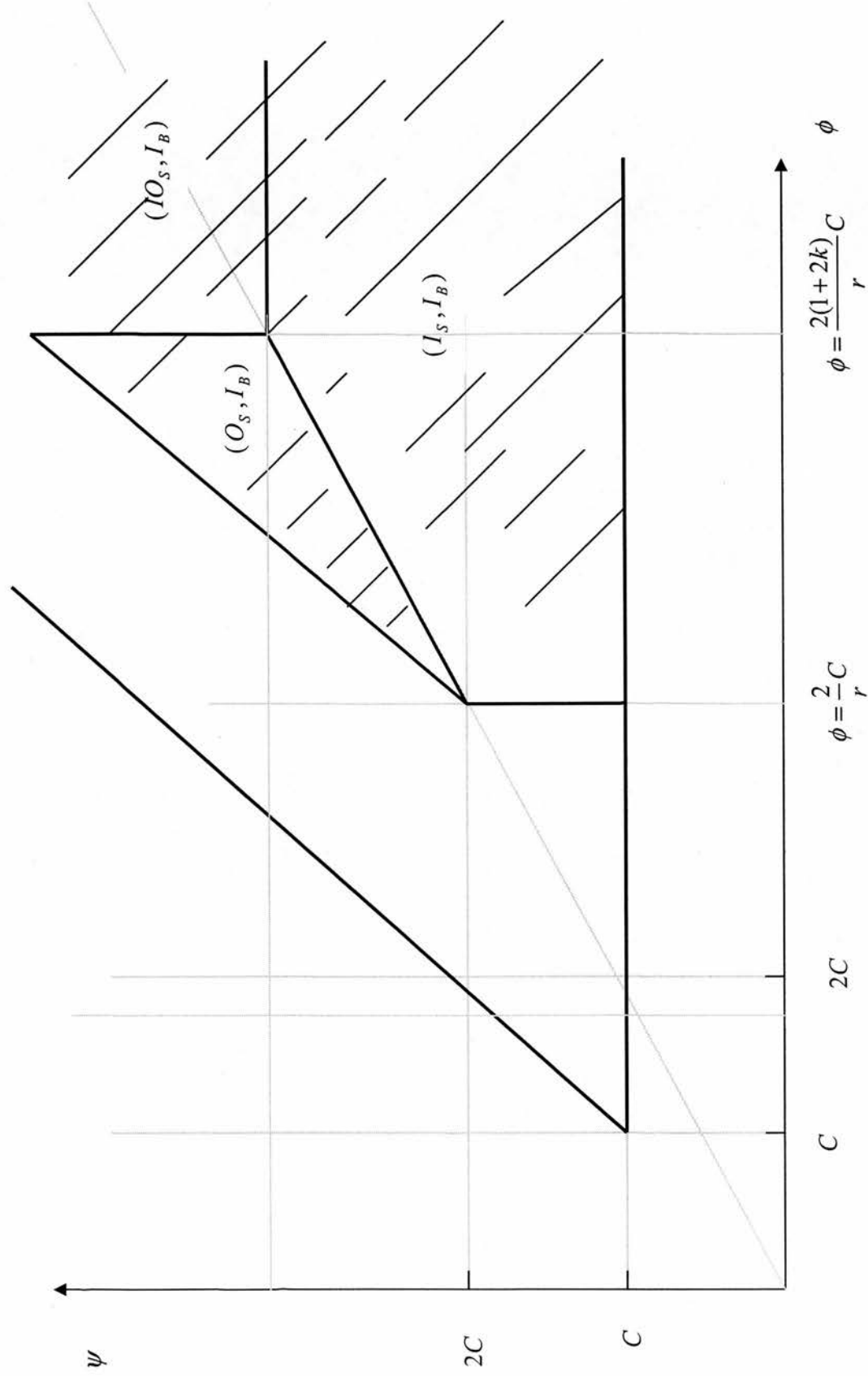
OPEN OFFER STOCKS					
PANEL 1-A					
TOTAL PRICE IMPACT					
	MEDIAN	LARGE		$ Total\ Im\ pact^{Median} - Total\ Im\ pact^{Large} $	
Pre offer purchase		2.08%		1.92%	0.16%
	T-ratio	80.79		44.97	3.16
Post offer purchase		2.73%		2.24%	0.50%
	T-ratio	70.83		37.20	6.93
PANEL 1-B					
TOTAL PRICE IMPACT					
	PRE OFFER	POST OFFER		$ Total\ Im\ pact^{Pre} - Total\ Im\ pact^{Post} $	
Median purchase		2.08%		2.73%	-0.66%
	T-ratio	80.79		70.83	-14.13
Median sale		-2.17%		-2.52%	-0.36%
	T-ratio	-80.48		-66.08	-7.61

A difference-in-means *t*-test is conducted to compare the average total price impact between median purchases and large purchases, and between pre-offer and post-offer. The *t* statistics is computed as $\frac{|\mu^A| - |\mu^B|}{\sqrt{Var^A + Var^B}}$.

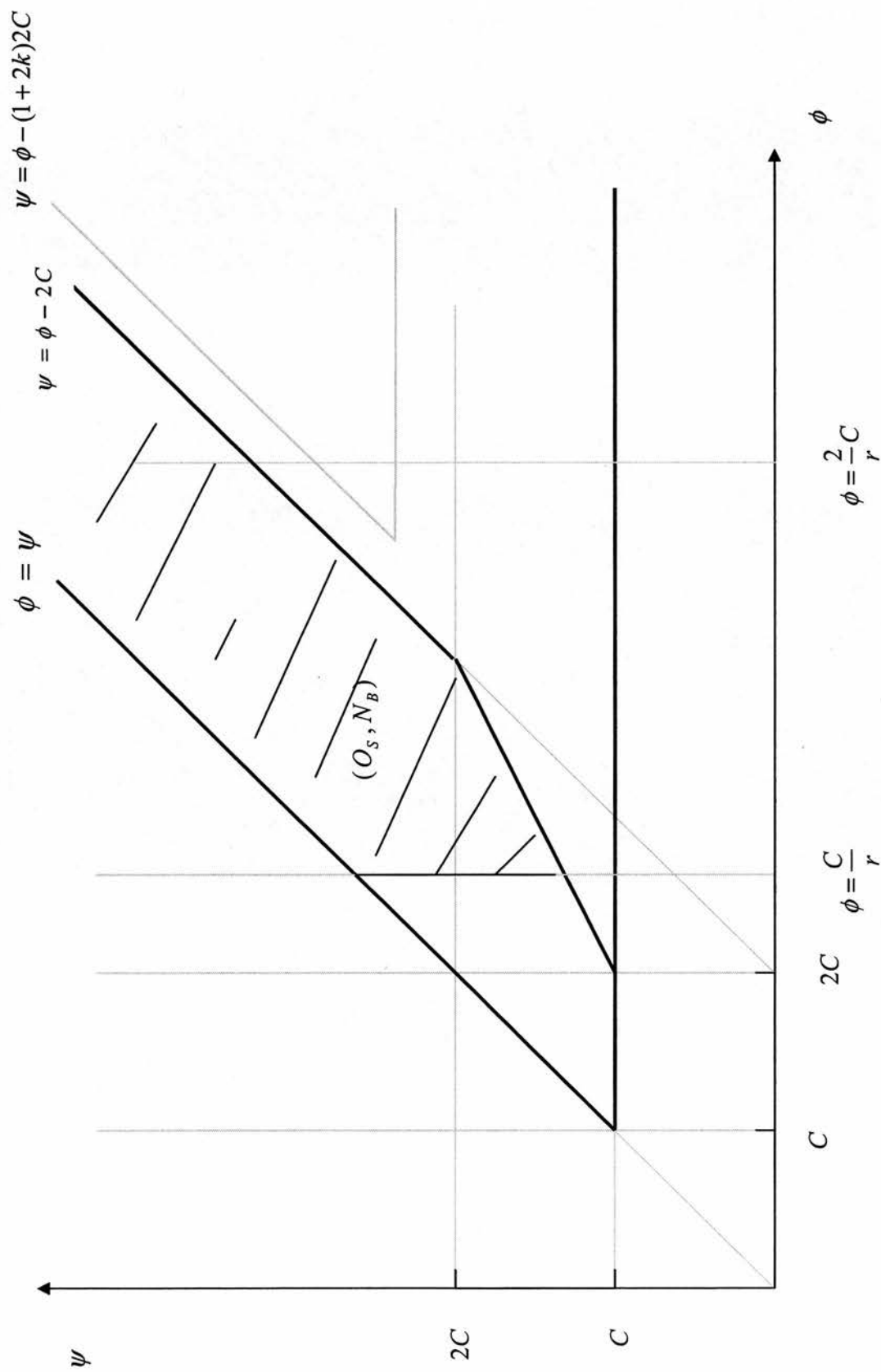
RIGHTS OFFER STOCKS
PANEL 2-A

163

Graph 4.1, Equilibrium (O_S, I_B) , (IO_S, I_B) , and (I_S, I_B) , given $r < 1$ and $k > 0$



Graph 4.2, Equilibrium (O_S, N_B) , given $r < 1$ and $k > 0$.



Bibliography

- Admati, A.R., Peiderer, P., 1988**, "A theory of intraday trading patterns," *Review of Financial Studies* 1, page 3-40.
- Admati, A., Peiderer, P., Zechner, J., 1994**, "Large shareholder activism, risk sharing, and "nancial market equilibrium," *Journal of Political Economy* 102, page 1097-1130.
- Aghion, P. and Bolton, P., 1987**, "Contracts as a Barrier to Entry," *American Economic Review* 77, page 388-401.
- Aghion, P., Dewatripont, M., and Rey, P., 1994**, "Renegotiation Design with Unverifiable Information," *Econometrica*, 62, page 257-282.
- Aghion, P. and Tirole, J., 1997**, "Formal and Real Authority in Organizations," *Journal of Political Economics*, 105, Pages: 1-29
- Alchian, A.A.**, "Corporate Management and Property Rights, in Economic Policy and the Regulation of Securities," (Washington D.C.: American Enterprise Institute, 1968).
- Armitage, S., 2000**, "The direct costs of UK rights issues and open offers," *European Financial Management*, 6, page 57-68.
- Armitage, S., 2002**, "Do underwriters certify Value? Evidence from UK rights issues and open offers," *Journal of Business Finance & Accounting*, 29(9) & (10), Nov./Dec. 2002,0306-686X.
- Armitage, S and Snell, A., 2003**, "Rights issues versus private placements: theory and UK evidence," Discussion paper 87, University of Edinburgh
- Baker, G., Gibbons, R., and Murphy, K.J., 2002**, "Relational Contracts and the Theory of the Firm," *Quarterly Journal of Economics*, 117, page 39-83.
- Barclay, M.J., 1997**, "Bid-ask spreads and the avoidance of odd-eighth quotes on Nasdaq: an examination of exchange listings," *Journal of Financial Economics* 45, page 35-60.
- Barclay, M.J. and Warner, J.B., 1993**, "Stealth trading and volatility: which trades move prices?," *Journal of Financial Economics* 34, page 281-306.
- Benston, G., Hagerman, R., 1974**, "Determinants of bid-asked spreads in the over-the-counter market," *Journal of Financial Economics* 1, page 353-364.
- Benveniste, L.M., Marcus, A.J., Wilhelm, W.J., 1992**, "What's special about the specialist? Floor exchange versus computerized market mechanisms," *Journal of Financial economics* 32, page 61-86.
- Bernheim, B.D. and Whinston, M.D., 1998**, "Exclusive Dealing," *Journal of Political Economy*, 106, page 64-103.
- Bessembinder, H., 1997**, "The degree of price resolution and equity trading costs," *Journal of Financial Economics* 45, page 9-34.
- Bhide, A., 1993**, "Hidden cost of stock market liquidity," *Journal of Financial Economics* 34, 31-51.
- Burkart, M., Gromb, D., Panunzi, F., 1997**, "Large shareholders, monitoring, and the value of the firm," *Quarterly journal of economics*. 112, page 693-728.
- Cao, C.; Ghysels, E.; and Hatheway, F., 2000**, "Price discovery without trading: Evidence from the Nasdaq pre-opening," *Journal of Finance* 55, page 1339-66.

- Chan, L., Lakonishok, J., 1993**, "Institutional trades and intra-day stock price behaviour," *Journal of Financial Economics* 33, page 173-200.
- Chemmanur, T.J., and P. Fulghieri, 1999**, "A theory of the going-public decision," *Review of Financial Studies* 12, page 249-279.
- Che, Y and Sakovics, J, 2004**, "A dynamic theory of Hold-up," *Econometrica*, 72, page 1063-1103
- Chung, T.-Y, 1991**, "Incomplete Contracts, Specific Investments, and Risk Sharing," *Review of Economic Studies*, 58, page 1031-1042
- Cronqvist, H., Nilsson, M., 2000**, "Why do public firms place equity privately? An empirical analysis," *Working paper (University of Chicago)*
- Cronqvist, Henrik, and Mattias Nilsson, 2005**, "The choice between rights offerings and private equity placements." *Journal of Financial Economics* 78:2, page 375-407.
- Demsetz, H., 1968**, "The cost of transacting," *Quarterly Journal of Economics* 82, page 33-53.
- De Meza, D. and Selvaggi, M., 2003**, "Exclusive Contracts Do Provide Investment Incentives," mimeo., London School of Economics, December.
- Desgranges, G. and Foucault, T., 2002**, "Price Improvements in Financial Markets as a Screening Device," THEMA Working Papers 2001-06,
- Dyck, Alexander and Zingales, Luigi, 2004**, "Private Benefits of Control: An International Comparison," *The Journal of Finance* 59 (2), page 537-600
- Easley, D. and O'Hara, M., 1987**, "Price, trade size, and information in securities markets," *Journal of Financial Economics* 19, page 69-90.
- Eckbo, E.B. and Masulis, R.W., 1992**, "Adverse selection and the rights offer paradox," *Journal of Financial Economics*, 32, page 293-332.
- Eckbo, E., and R. Masulis, 1995**, "Seasoned equity offerings: a survey", in R. Jarrow, V. Maksimovic and W. Ziemba, eds., *Handbooks in Operations Research and Management Science* (Elsevier, Amsterdam) Chapter 31.
- Eckbo E and, Norli O, 2004**, "The choice of seasoned-equity selling mechanism: Theory and evidence," CEPR Discussion Paper No. 4833
- Edlin, A. and Reichelstein, S., 1996**, "Holdups, Standard Breach Remedies, and Optimal investment," *American Economic Review*, 86, page 478-501.
- Frasco, G, 1991**, "Exclusive Dealing: A Comprehensive Case Study," London: University Press of America, 1991.
- Gamill, James F., 1989**, "The organization of financial markets: Competitive versus cooperative market mechanisms," Working paper (Harvard Business School. Boston, M.A.).
- Gemmell, G., 1996**, "Transparency and liquidity: a study of block trades on the london stock exchange under different publication rules," *Journal of Finance* 51, page 1765-1790.
- Giammarino, Ronald M., and Tracy Lewis, (1989)**, "A theory of negotiated equity financing," *Review of Financial Studies* 2, page 265-288.
- Glosten, Larry R. and Paul Milgrom, 1985**, "Bid, ask and transactions prices in a specialist market with heterogeneously informed traders," *Journal of Financial Economics* 14, 71-100.

Glosten, L.R. and Harris, L., 1988, "Estimating the components of the bid ask spread," *Journal of Financial Economics* 14, page 21-142.

Grossman, S., and Hart, O., 1980, "Takeover bids, the free-rider problem, and the theory of the corporation," *Bell Journal of Economics* 11, page 42-64.

Grossman, S.J. and Hart, O.D., 1986, "The Costs and Benefits of Ownership: A Theory of Vertical and Lateral Integration," *Journal of Political Economy*, 94, page 691-719.

Hansch, O., Naik, N. and Vishwanathan, S., 1998, "Do inventories matter in dealership markets: evidence from the London stock exchange," *Journal of Finance* 53, page 1623-1656.

Hart, O., 1995, "Firms, Contracts, and Financial Structure," Oxford University Press: London.

Hart, O.D and Moore, J., 1990, "Property Rights and the Nature of the Firm," *Journal of Political Economy*, Vol. 98 (1990), page. 1119-1158.

Hart, O D and Moore, J., 1999, "Foundation of incomplete contracts," *Review of economic studies*, 66, page 115-138.

Hermalin, B., 1987, "Adverse effects of the threat of takeovers," MIT mimeo

Hertzel, Michael, and Richard L. Smith, 1993, "Market discounts and shareholder gains for placing equity privately," *Journal of Finance* 48, page 459-485.

Holmstrom, B., 1979, "Moral Hazard and Observability," *The Bell Journal of Economics*, 10, page 74-91.

Holmstrom, Bengt, and Tirole, Jean, 1989, 'The Theory of the Firm,' in Schmalensee, Richard and Willig, Robert D. (eds.), *Handbook of Industrial Economics*. New York: Elsevier Science Publishing. Page 61-133.

Holmstrom, b. and Tirole, j., 1993, "Market liquidity and performance monitoring," *Journal of Political Economy* 101, page 678-709

Holthausen, R.W., Leftwich, R.W. and Mayers, D., 1987, "The Effect of Large Block Transactions on Security Prices - A Cross-Sectional Analysis," *Journal of Financial Economics*, 19, page 237-267.

Holthausen, R.W., Leftwich, R.W. and Mayers, D, 1990, "Large-Block Transactions, the Speed of Response, and Temporary and Permanent Stock-Price Effects," *Journal of Financial Economics*, 46, page 71-95.

Huang, R. and Stoll, H., 1997, "The components of the bid-ask spread: a general approach," *Review of Financial Studies*, 10, page 995-1034.

Huddart, S., 1993, "The effect of a large shareholder on corporate value," *Management Science*, 39, page 1407-1421.

Jensen, M. and Meckling, W., 1976, "Theory of the firm: managerial behavior, agency costs, and ownership structure," *Journal of Financial Economics*, 3, page 305-360.

Jensen, Michael C., 1986, "Agency costs of free cash flow, corporate finance and takeovers," *American Economic Review*, 76, page 323-329.

Kahn, C. and Winton, A., 1998, "Ownership structure, speculation, and shareholder intervention," *Journal of Finance*, 53, page 99-129.

Kenneth, B. and O'Hara, M., 1987, "Building blocks: An introduction to block trading," *Journal of Banking and Finance* 11, page 193-212.

- Klein, B., 1988**, "Vertical Integration as Organizational Ownership: The Fisher Body—General Motors Relationship Revisited," *Journal of Law, Economics and Organization*, 4, page 199–213.
- Klein, B., Crawford, R., and Alchian, A., 1978**, "Vertical Integration, Appropriable Rents, and the Competitive Contracting Process," *Journal of Law and Economics*, 21, page 297–326.
- Keim, D.B. and Madhavan, A., 1996**, "The upstairs market for large-block transactions: analysis and measurement of price effects," *Review of Financial Studies*, 9, page 1–36.
- Kothare M., 1997**, "The effects of equity issues on ownership structure and stock liquidity: A comparison of rights and public offerings," *Journal of Financial Economics*, 43, page 131–148
- Koski JL and Michaely R., 2000**, "Prices, liquidity, and the information content of trades," *Review of Financial Studies*, 13, Page. 659–696
- Kyle, A., 1985**, "Continuous auctions and insider trading," *Econometrica*, 53, page 1315–1335.
- Kyle, A.S. and Vila, J.-L., 1991**, "Noise trading and takeovers," *Rand Journal of Economics* 22, page 54–71.
- Laffont, J.-J and Tirole, J., 1987**, "Repeated auctions of incentive contracts, investment and bidding party, with an application to takeovers," Discussion paper, No.463, MIT
- La Porta, R. Lopez-de-Silanes, F. and Shleifer, A., 1999**, "Corporate ownership around the world," *Journal of Finance*, 54, page 471–517.
- Lockwood and Linn, 1990**, "An Examination of Stock Market Return Volatility During Overnight and Intraday Periods, 1964–1989," *The Journal of Finance*, 1990, page 591–601
- Loderer, C.F., D.P. Sheehan and G.B. Kadlec, 1991**, "The pricing of equity offerings," *Journal of financial economics*, 29, page 35–57.
- Loughran, Tim, and Jay R. Ritter, 1995**, "The new issues puzzle," *Journal of Finance*, 50, page 23–51.
- Mace, M., 1971**, "Directors: Myth and reality," Graduate school of business administration, Harvard University
- Madhavan, A., Richardson, M. and Roomans, M., 1997**, "Why do security prices fluctuate? a transaction-level analysis of NYSE stocks," *Review of Financial Studies*, 10, page 1035–1064.
- Marvel, H.P., 1982**, "Exclusive Dealing," *Journal of Law and Economics*, 25, page. 1–25.
- Masten, S.E. and Snyder, E.A., 1993**, "United States versus United Shoe Machinery Corporation: On the Merits," *Journal of Law and Economics*, 36, page. 33–70.
- Masulis, Ronald W. and Ashok N. Korwar, 1986**, "Seasoned equity offerings: An empirical investigation," *Journal of Financial Economics*, 15, page 91–118.
- Matthewson, F. and Winter, R., 1987**, "The Competitive Effect of Vertical Agreements: Comment," *American Economic Review*, 77, page 1057–1062.
- Matthew Rhodes-Kropf, 2005**, "Price Improvement in Dealership Markets," *The Journal of Business*, 78, page 1137–1172
- Maug, E., (1998)**, "Large shareholders as monitors: is there a trade-off between liquidity and control?," *Journal of Finance*, 53, page 65–98.

Morck, R., Shleifer, A. and Vishny, R., 1988, "Management ownership and market valuation: an empirical analysis," *Journal of Financial Economics*, 20, page 293-315.

Myers, S.C. and Majluf, N.S., 1984, "Corporate financing and investment decisions when firms have information that investors do not have," *Journal of Financial Economics*, 13, page 187-221.

Modigliani, F. and Miller, M.H., 1958, "The Cost of Capital, Corporation Finance, and the Theory of Investments," *American Economic Review*, 48, page. 261-297.

Modigliani, F. and Miller, M.H., 1961, "Dividend policy, growth, and the valuation of shares," *Journal of Business*, 34, page. 411-433.

Nenova, T., 2003, "The value of corporate voting rights and control: a cross-country analysis," *Journal of Financial Economics*, 68 , page 325-351

Nöldeke, G., and Schmidt, K.M., 1995, "Option Contracts and Renegotiation: A Solution to the Hold-Up Problem," *RAND Journal of Economics*, 26, page 163-179

Nöldeke, G and Schmidt, K., 1998, "Sequential Investments and Options to Own," *The RAND Journal of Economics*, 29, page 633-653.

Pagano, M. and Röell, A., 1998. "The choice of stock ownership structure: agency costs, monitoring and the decision to go public," *Quarterly Journal of Economics* 113, page 187-226.

Reiss, P.C. and Werner, I., 1998, "Inter-dealer trading: evidence from London," *Journal of Finance*, 53, page 1657-1704.

Rasmusen, E.B., Ramseyer, J.M., And Wiley, Jr. J.S, 1991, "Naked Exclusion," *American Economic Review*, 81, page. 1137-1145.

Robert Heinkel and Eduardo S. Schwartz, 1986, "Rights Versus Underwritten Offerings: An Asymmetric Information Approach," *Journal of finance*, 41, page. 1-18

Saar, G., 2001, "Price Impact Asymmetry of Block Trades: An Institutional Trading Explanation," *The Review of Financial Studies*, 2001, page 1153-1181

Segal, I.R. and Whinston, M.D, 2000a, "Exclusive Dealing and Protection of Investments," *RAND Journal of Economics* 31, page 603-633

Segal, I. and Whinston M, 2000b, "Naked Exclusion: Comment," *American Economic Review*, 90(1), page 296-309.

Shavell, S., 1979, "Risk sharing and incentives in the principal-agent relationship," *Bell Journal of Economics*, Spring 1979, page 55-73.

Shleifer, A., and Vishny, R W, 1986, "Large Shareholders and Corporate Control." *Journal of Political economy* 94, page 461-88.

Slovin, M.B., M.E. Sushka, and K.W.L. Lai, 2000, "Alternative flotation methods, adverse selection, and ownership structure: Evidence from seasoned equity issuance in the UK", *Journal of Financial Economics*, 57, page. 157-190.

Smith, C.W., Jr., 1977, "Alternative methods for raising capital rights versus underwriting offerings", *Journal of financial economics*, 5, page 273-307

Snell, A, and Tonks, I, 1998, "Testing for asymmetric information and inventory control effects in market maker behaviour on the London Stock Exchange," *Journal of Empirical Finance*, 5(1), pages 1-25, January.

Stein, J.C., 1988, "Takeover Threats and Managerial Myopia," *The Journal of Political Economy*, 96, page 61-80.

Stoll, H., 1978, "The supply of dealer services in securities markets," *Journal of Finance*, 33, page 1133-1151.

White, Halbert, 1980, "A heteroskedasticity-consistent covariance matrix estimator and a direct test for heteroscedasticity," *Econometrica*, 48, page 817-838.

Williamson, O, 1985, "The Economic Institutions of Capitalism," The Free Press, New York.

Wruck, K., 1989, "Equity ownership concentration and firm value," *Journal of Financial Economics*, 23, page 3-28.

Wu Y, 2004, "The choice of equity-selling mechanisms," *Journal of financial economics*, 74, page 93-119

Appendix A

A.1 Regression results for specification:

$$\text{Spread}(\%) = \beta_0 + \beta_1 \ln(\text{Firm size}) + \beta_2 \ln(\text{Trading Volume}) + \beta_3 D_P + \beta_4 D_R + \beta_5 D_{PR} + \varepsilon$$

Dependent Variable	Volume Weighted Effective Spread	Simple Effective Spread	Time Weighted Quoted Spread	Simple Quoted Spread
Independent variables:				
Constant	0.36	0.34	0.37	0.40
	T ratio	9.36	9.51	9.28
Log of Market Capitalization	-0.0057	-0.0049	-0.0053	-0.0056
	T ratio	-2.47	-2.35	-2.29
1/Price				
	T ratio			
Log of Pounds Volume per day	-0.01	-0.01	-0.01	-0.01
	T ratio	-5.32	-5.33	-5.58
Log of Mid quote variation				
	T ratio			
Dummy for Post	0.0014	0.0048	0.0087	0.0077
	T ratio	0.21	0.72	1.13
Dummy for Right offer	-0.0099	-0.0079	-0.0077	-0.0093
	T ratio	-1.05	-0.84	-0.79
Interactive Dummy for Post and Right	0.0018	-0.0039	-0.0059	-0.0035
	T ratio	0.14	-0.31	-0.44
R square	0.36	0.33	0.33	0.34
T Test $\beta_5 + \beta_7 = 0$				
	Test T ratio	0.29	0.09	0.25

A.2 Regression results for specification: $\Delta Spread = \beta_0 + \beta_1 \Delta Firm\ size + \beta_3 \Delta Volume + \varepsilon$

Dependent Variable	Changes in Volume weighted effective spread				Changes in Time weighted quoted spread				Changes in quoted spread			
	Open offers	Rights offers	Open offers	Rights offers	Open offers	Rights offers	Open offers	Rights offers	Open offers	Rights offers	Open offers	Rights offers
Constant	0.08	0.23	0.12	0.09	0.14	0.12	0.14	0.12	0.14	0.12	0.14	0.12
Changes in market capitalization T statistics	1.46	1.31	3.45	1.34	3.83	2.30	4.33	2.47	4.33	2.47	4.33	2.47
Changes in Price level T statistics	-0.28	-0.96	-0.32	-0.46	-0.20	-0.26	-0.24	-0.32	-0.24	-0.32	-0.24	-0.32
Changes in Pound Volume T statistics	-1.97	-1.54	-3.50	-1.76	-2.18	-1.24	-2.44	-1.54	-2.44	-1.54	-2.44	-1.54
Changes in Mid quote variation T statistics	-0.10	0.02	-0.07	-0.07	-0.08	-0.13	-0.08	-0.09	-0.08	-0.09	-0.08	-0.09
R square	0.11	0.16	0.22	0.24	0.15	0.42	0.20	0.38	0.20	0.38	0.20	0.38

A.3 Comparison of information content of trades between open-offer and rights-offer stocks

Excess Return Window	PRE/POST	Median/Large trades	Permanent impact of open offer stocks	Permanent impact of rights offer stocks	Significance of the difference between open-offer stocks and rights offer stocks,
			T Statistics in Bracket	T Statistics in Bracket	T statistics (one-sided P value below)
(From - 5 trade to +5 trade)	PRE	Median	0.3549% 13.52	0.3374% 5.709	0.28131 0.389235
		Large	0.4772% 12.72	0.42% 5.069	0.617971 0.2683
	POST	Median	0.3014% 10.85	0.2272% 4.675	1.393484 0.08174
		Large	0.4468% 10.92	0.39% 5.709	0.689453 0.24527
(-4, +4)	PRE	Median	0.3142% 14.17	0.3017% 5.922	0.232688 0.408
		Large	0.4391% 13.66	0.3727% 5.256	0.867762 0.192765
	POST	Median	0.2709% 11.45	0.1888% 4.67	1.840035 0.032885
		Large	0.3999% 11.58	0.3319% 5.601	1.014395 0.1552
(-3, +3)	PRE	Median	0.2631% 14.62	0.2234% 5.465	0.917409 0.179465
		Large	0.3755% 14.13	0.3278% 5.699	0.764936 0.222155
	POST	Median	0.2214% 11.56	0.1679% 5.231	1.50 0.066435
		Large	0.3684% 13.1	0.2840% 5.757	1.518098 0.0645
(-2, +2)	PRE	Median	0.2057% 14.84	0.1777% 5.963	0.880401 0.189325
		Large	0.3167% 15.49	0.2413% 5.582	1.600029 0.0548
	POST	Median	0.1814% 12.59	0.1313% 5.562	1.897584 0.02888
		Large	0.3030% 14.32	0.2322% 6.405	1.719357 0.04278

(-1, +1)	PRE	Median	0.1228%	0.1079%	0.774098
			14.54	6.01	0.21944
		Large	0.2251%	0.1962%	0.911207
			15.61	6.839	0.181095
	POST	Median	0.1207%	0.0809%	2.319698
			12.99	5.316	0.01018
		Large	0.2224%	0.1596%	2.310433
			15.32	6.8	0.010435

Appendix B:

Proposition 2: (O_S, I_B) is equilibrium if and only if $\phi - \psi$ pair satisfies

$$\text{Max}\left\{\frac{2C}{1-r}, 4C\right\} \leq \phi \leq \frac{2(1+2k)C}{r}, \text{ and } \text{Max}\{r\phi, 2C\} \leq \psi \leq \phi - 2C.$$

Proof: Equilibrium (O_S, I_B) exists if and only if given some value of r, k that satisfy the assumptions, there exists feasible values of ϕ, ψ and C that make the following four inequalities satisfied simultaneously:

$$\left\{ \begin{array}{l} \frac{1}{2}\phi + \frac{1}{2}\psi - C \geq \frac{1}{2}\phi \quad (1) \\ \frac{1}{2}\phi + \frac{1}{2}\psi - C \geq \frac{1+r}{2}\phi - C \quad (2) \\ \frac{1}{2}\phi + \frac{1}{2}\psi - C \geq \frac{1+r}{2}\phi + \frac{1}{2}\psi - 2(1+k)C \quad (3) \\ \frac{\phi - \psi}{2} - C \geq 0 \quad (4) \end{array} \right.$$

Simplifying these yields:

$$\left\{ \begin{array}{l} \psi \geq 2C \quad (5) \\ \psi \geq r\phi \quad (6) \\ \phi \leq \frac{2(1+2k)C}{r} \quad (7) \\ \psi \leq \phi - 2C \quad (8) \end{array} \right.$$

(5) and (8) imply $\phi \geq 4C$. With (6) and (8), we have $\phi - 2C \geq \psi \geq r\phi$. This requires $\phi - 2C \geq r\phi$. To satisfy $\phi - 2C \geq r\phi$, we need $\phi \geq \frac{2C}{1-r}$.

Summarizing all these inequalities yields $\text{Max}\left\{\frac{2C}{1-r}, 4C\right\} \leq \phi \leq \frac{2(1+2k)C}{r}$,

and $\text{Max}\{r\phi, 2C\} \leq \psi \leq \phi - 2C$.

Q.E.D.

Corollary 1: Equilibrium (O_S, I_B) exists only if one of the following sets of conditions is satisfied:

- $-\frac{1}{4} \leq k < 0$ and $r \leq \frac{1}{2} + k$
- $k \geq 0$ and $r \leq 1 - \frac{1}{2(1+k)}$

Proof: To satisfy (5), (7) and (8), it requires that in the $\phi - \psi$ space, the ϕ where $\psi = 2C$ and $\psi = \phi - 2C$ intersect be smaller than $\frac{2(1+2k)C}{r}$, which requires:

$$r \leq \frac{1}{2} + k \quad (9)$$

Given (9), to satisfy (6), it requires, in the $\phi - \psi$ space, the ψ where $\psi = r\phi$ and $\phi = \frac{2(1+2k)C}{r}$ intersect be smaller than that where $\psi = \phi - 2C$ and $\phi = \frac{2(1+2k)C}{r}$ intersect, which requires:

$$r \leq 1 - \frac{1}{2(1+k)} \quad (10)$$

When $k \geq 0$, (10) is binding; when $-\frac{1}{2} < k < 0$, (9) is binding.

Since $1 - \frac{1}{2(1+k)}$ and $\frac{1}{2} + k$ are below 1 given the range of k , equilibrium (O_S, I_B) exists only if

investment is substitutable. By assumption, $\phi > \frac{C}{r}$ in this case. Therefore, for the equilibrium to exist, the following inequality must be satisfied:

$$\frac{2(1+2k)C}{r} > \frac{C}{r} \Rightarrow k > -\frac{1}{4} \quad (11)$$

As a result, for $-\frac{1}{4} \leq k < 0$, there exists ϕ, ψ and C that satisfy (1 - 4) if and only if $r \leq \frac{1}{2} + k$;

for $k \geq 0$, there exists ϕ, ψ and C that satisfy (1 - 4) if and only if $r \leq 1 - \frac{1}{2(1+k)}$.

Q.E.D.

Corollary 2: Assume $\phi \geq \frac{2C}{r}$, equilibrium (O_S, I_B) exists only if $k \geq 0$ and $r \leq 1 - \frac{1}{2(1+k)}$. For

such k and r , (O_S, I_B) is equilibrium if and only if $\phi - \psi$ pair satisfies $\frac{2C}{1-r} \leq \phi \leq \frac{2(1+2k)C}{r}$,

and $r\phi \leq \psi \leq \phi - 2C$.

Proof: Continue with the argument in the proof of Corollary 1. When $\phi \geq \frac{2C}{r}$, inequality (11) is

revised as $\frac{2(1+2k)C}{r} > \frac{2C}{r}$, which requires:

$$k \geq 0 \quad (12)$$

Apply Corollary 1, the condition for r is $r \leq 1 - \frac{1}{2(1+k)}$.

Inequality (5) and (8) imply $\phi - 2C \geq 2C$. With (6) and (8), we have $\phi - 2C \geq \psi \geq r\phi$. This requires $\phi - 2C \geq r\phi$. When $\phi \geq \frac{2C}{r}$, $r\phi \geq 2C$. Therefore, $\phi - 2C \geq 2C$ is not binding. The

lower bound for ϕ is $\phi \geq \frac{2C}{1-r}$.

When $\phi \geq \frac{2C}{r}$, $\psi \geq r\phi$ is sufficient for $\psi \geq 2C$. The lower bound for ψ is $\psi \geq r\phi$.

These yield the range of $\phi - \psi$ pair: $\frac{2C}{1-r} \leq \phi \leq \frac{2(1+2k)C}{r}$, and $r\phi \leq \psi \leq \phi - 2C$.

Q.E.D

Proposition 3: Equilibrium (O_S, N_B) exists if and only if one of the following sets of conditions is satisfied:

- $k \geq 0$, $\phi > \text{Max}\{C, \frac{C}{r}\}$, $\text{Max}\{\frac{1}{2}\phi, \phi - 2C, C\} \leq \psi < \phi$
- $-\frac{1}{2} < k < 0$, $\phi > \text{Max}\{C, \frac{C}{r}\}$, $\text{Max}\{\frac{1}{2}\phi, \phi - 2(1+2k)C, C\} \leq \psi < \phi$

Proof: Equilibrium (O_S, N_B) exists if and only if given some value of r, k , there exists feasible value of ϕ, ψ and C that make the following four inequalities satisfied simultaneously:

$$\left\{ \begin{array}{l} \psi - C \geq 0 \quad (14) \\ \psi - C \geq \frac{1}{2}\phi - C \quad (15) \\ \psi - C \geq \frac{1}{2}\phi + \frac{1}{2}\psi - 2(1+k)C \quad (16) \\ 0 \geq \frac{1}{2}(\phi - \psi) - C \quad (17) \end{array} \right.$$

(14) is satisfied by assumption. To satisfy (15-17), it requires:

$$\left\{ \begin{array}{l} \psi \geq \frac{1}{2}\phi \quad (18) \\ \psi \geq \phi - 2(1+2k)C \quad (19) \\ \psi \geq \phi - 2C \quad (20) \end{array} \right.$$

First assume $k \geq 0$. With (20), (19) is non-binding if equilibrium exists. Equilibrium exists if and only if $\phi - \psi$ pair satisfies $\phi > \text{Max}\{C, \frac{C}{r}\}$ and $\text{Max}\{\frac{1}{2}\phi, \phi - 2C, C\} \leq \psi < \phi$.

Next assume $-\frac{1}{2} < k < 0$. With (19), (20) is non-binding. Equilibrium exists if and only if $\phi - \psi$ pair satisfies $\phi > \text{Max}\{C, \frac{C}{r}\}$ and $\text{Max}\{\frac{1}{2}\phi, \phi - 2(1+2k)C, C\} \leq \psi < \phi$.

Q.E.D

Proposition 4: Equilibrium (IO_S, I_B) exists if and only one of the following sets of condition is satisfied:

- $k \geq 0, \phi \geq \frac{2(1+2k)C}{r}$ and $\psi \geq (2+4k)C$.
- $-\frac{1}{4} \leq k < 0, \phi \geq \frac{2}{r}C$ and $\psi \geq (2+4k)C$
- $-\frac{1}{2} < k < -\frac{1}{4}, \phi \geq \frac{2}{r}C$ and $\psi > C$

Proof: Equilibrium (IO_S, I_B) exists if and only if given some value of r, k , there exists feasible value of ϕ, ψ and C that make the following four inequalities satisfied simultaneously:

$$\left\{ \begin{array}{l} \frac{1+r}{2}\phi + \frac{1}{2}\psi - 2(1+k)C \geq \frac{1}{2}\phi \quad (21) \\ \frac{1+r}{2}\phi + \frac{1}{2}\psi - 2(1+k)C \geq \frac{1}{2}\phi + \frac{1}{2}\psi - C \quad (22) \\ \frac{1+r}{2}\phi + \frac{1}{2}\psi - 2(1+k)C \geq \frac{1+r}{2}\phi - C \quad (23) \\ \frac{(1+r)\phi - \psi}{2} - C \geq \frac{1}{2}(\phi - \psi) \quad (24) \end{array} \right.$$

Simplifying the above yields:

$$\left\{ \begin{array}{l} \psi \geq 4(1+k)C - r\phi \quad (25) \\ \phi \geq \frac{2(1+2k)C}{r} \quad (26) \\ \psi \geq (2+4k)C \quad (27) \\ \phi \geq \frac{2}{r}C \quad (28) \end{array} \right.$$

The right hand side of (25) takes maximum value $(2+4k)C$ when $\phi = \frac{2}{r}C$. By (27), (25) is non-binding if the equilibrium exists.

For $k \geq 0$, (26-28) are satisfied if and only if $\phi \geq \frac{2(1+2k)C}{r}$ and $\psi \geq (2+4k)C$.

For $-\frac{1}{4} \leq k < 0$, (26-28) are satisfied if and only if $\phi \geq \frac{2}{r}C$ and $\psi \geq (2+4k)C$.

For $-\frac{1}{2} < k < -\frac{1}{4}$, (26-28) are satisfied if and only if $\phi \geq \frac{2}{r}C$ and $\psi > C$.

Q.E.D

Proposition 5: Equilibrium (I_S, I_B) exists only if $k > -\frac{1}{4}$. For k satisfies this condition, (I_S, I_B)

is equilibrium if and only if $C < \psi \leq (2+4k)C$ and $\phi \geq \text{Max}\{\frac{2C}{r}, \frac{1}{r}\psi\}$.

Proof: Equilibrium (I_S, I_B) exists if and only if given some value of r, k , there exists feasible value of ϕ, ψ and C that make the following four inequalities satisfied simultaneously:

$$\left\{ \begin{array}{l} \frac{1+r}{2}\phi - C \geq \frac{1}{2}\phi \quad (29) \\ \frac{1+r}{2}\phi - C \geq \frac{1}{2}\phi + \frac{1}{2}\psi - C \quad (30) \\ \frac{1+r}{2}\phi - C \geq \frac{1+r}{2}\phi + \frac{1}{2}\psi - 2(1+k)C \quad (31) \\ \frac{1+r}{2}\phi - C \geq \frac{1}{2}\phi \quad (32) \end{array} \right.$$

Simplifying the above yields:

$$\left\{ \begin{array}{l} \phi \geq \frac{2C}{r} \quad (33) \\ \psi \leq r\phi \quad (34) \\ \psi \leq (2+4k)C \quad (35) \end{array} \right.$$

To satisfy (35), it requires:

$$(2+4k)C > C \Rightarrow k > -\frac{1}{4} \quad (36)$$

Given (36), to satisfy (33-35), for some $\psi \in (C, (2+4k)C]$, there must exist $\phi \geq \frac{2}{r}C$ such that $r\phi \geq \psi$. This is always true, given assumption $r > 0$.

Q.E.D

Equilibrium (I_S, N_B) exists if and only if $r \leq 1$, $k > -\frac{1}{4}$, and $\phi - \psi$ pair satisfies $\text{Max}\{2C, \frac{C}{r}\} < \phi \leq \frac{2C}{r}$ and $C < \psi \leq \text{Min}\{\frac{1}{2}\phi, 2C + 4kC\}$.

Proof. Equilibrium (I_S, N_B) exists if and only if given some value of r, k , there exists feasible value of ϕ, ψ and C that make the following four inequalities satisfied simultaneously:

$$\left\{ \begin{array}{l} \frac{1}{2}\phi - C \geq 0 \quad (37) \\ \frac{1}{2}\phi - C \geq \psi - C \quad (38) \\ \frac{1}{2}\phi - C \geq \frac{1}{2}\phi + \frac{1}{2}\psi - 2(1+k)C \quad (39) \\ \frac{1}{2}\phi \geq \frac{1+r}{2}\phi - C \quad (40) \end{array} \right.$$

Given assumption $\psi > C$ and (38), (37) is non-binding. Simplifying the above yields:

$$\left\{ \begin{array}{l} \psi \leq \frac{1}{2}\phi \quad (41) \\ \psi \leq 2C + 4kC \quad (42) \\ \phi \leq \frac{2C}{r} \quad (43) \end{array} \right.$$

Given assumption $\psi > C$, (42) can be satisfied only if

$$2C + 4kC > C \Rightarrow k > -\frac{1}{4} \quad (44)$$

To satisfy (41-43), in $\phi - \psi$ space, the ϕ where $\psi = \frac{1}{2}\phi$ and $\psi = C$ intersect must be smaller than $\frac{2C}{r}$, which requires:

$$2C \leq \frac{2C}{r} \Rightarrow r \leq 1 \quad (45)$$

Q.E.D

Equilibrium (IO_S, N_B) exists if and only if one of the following two sets of conditions is satisfied:

- $k > -\frac{1}{4}$, $r \leq \frac{1}{2(1+2k)}$, and $\phi - \psi$ pair satisfies $\text{Max}\{4(1+2k)C, \frac{C}{r}\} < \phi \leq \frac{2C}{r}$ and $(1+2k)2C \leq \psi \leq \phi - (2+4k)C$.
- $-\frac{1}{4} \geq k > -\frac{1}{2}$, $r < \frac{2}{3+4k}$ and $\phi - \psi$ pair satisfies

- For $1 \leq r < \frac{2}{3+4k}$, $(3+4k)C < \phi \leq \frac{2C}{r}$ and $C < \psi \leq \phi - (2+4k)C$.
- For $r < 1$, $\text{Max}\{(3+4k)C, \frac{C}{r}\} < \phi \leq \frac{2C}{r}$ and $C < \psi \leq \phi - (2+4k)C$.

Proof. Equilibrium (IO_S, N_B) exists if and only if given some value of r, k , there exists feasible value of ϕ, ψ and C that make the following four inequalities satisfied simultaneously:

$$\left\{ \begin{array}{l} \frac{1}{2}\phi + \frac{1}{2}\psi - 2(1+k)C \geq 0 \quad (46) \\ \frac{1}{2}\phi + \frac{1}{2}\psi - 2(1+k)C \geq \psi - C \quad (47) \\ \frac{1}{2}\phi + \frac{1}{2}\psi - 2(1+k)C \geq \frac{1}{2}\phi - C \quad (48) \\ \frac{\phi - \psi}{2} \geq \frac{(1+r)\phi - \psi}{2} - C \quad (49) \end{array} \right.$$

With (47), (46) is non-binding if the equilibrium exists. Simplifying the above yields:

$$\left\{ \begin{array}{l} \psi \leq \phi - (2+4k)C \quad (50) \\ \psi \geq 2C + 4kC \quad (51) \\ \phi \leq \frac{2C}{r} \quad (52) \end{array} \right.$$

For $k > -\frac{1}{4}$, to satisfy (50-52), in $\phi - \psi$ space, the ϕ where $\psi = \phi - (2+4k)C$ and

$\psi = 2C + 4kC$ intersect must be no larger than $\frac{2C}{r}$, which requires:

$$(1+2k)4C \leq \frac{2C}{r} \Rightarrow r \leq \frac{1}{2(1+2k)} \quad (53)$$

For $-\frac{1}{4} \geq k > -\frac{1}{2}$, to satisfy (50-52), in $\phi - \psi$ space, the ϕ where $\psi = \phi - (2+4k)C$ and

$\psi = C$ intersect must be smaller than $\frac{2C}{r}$, which requires:

$$3C + 4kC < \frac{2C}{r} \Rightarrow r < \frac{2}{3+4k} \quad (54)$$

To ensure at least some of the $\phi - \psi$ pair satisfying (50-52) also satisfies $\phi > \psi$, we require:

$$\frac{2C}{r} > 2C + 4kC \Rightarrow r < \frac{1}{1+2k} \quad (55)$$

Given (53) or (54), (55) is not binding.

Q.E.D

Equilibrium (N_S, I_B) exists only if $r \leq 1$ and one of the following sets of conditions is satisfied:

- $k \geq 0, \text{Max}\{2C, \frac{C}{r}\} < \phi \leq \frac{2C}{r} \text{ and } C < \psi \leq 2C$
- $0 > k > -\frac{1}{4}, r \leq \frac{1}{2}, \frac{C}{r} < \phi \leq \frac{2C}{r} \text{ and } C < \psi \leq \text{Min}\{2C, -r\phi + 4(1+k)C\}$
- $0 > k > -\frac{1}{4}, 1 > r > \frac{1}{2}, 2C < \phi < \frac{2C}{r} \text{ and } C < \psi \leq \text{Min}\{2C, -r\phi + 4(1+k)C\}$
- $-\frac{1}{4} \geq k > -\frac{1}{2}, r \leq \frac{1}{2}, \frac{C}{r} < \phi < \frac{(3+4k)C}{r} \text{ and } C < \psi \leq -r\phi + 4(1+k)C$
- $-\frac{1}{4} \geq k > -\frac{1}{2}, 1 > r > \frac{1}{2}, \text{ and } r < \frac{3}{2} + 2k. \phi, \psi \text{ satisfy } 2C < \phi < \frac{(3+4k)C}{r} \text{ and } C < \psi \leq -r\phi + 4(1+k)C$

Proof: Equilibrium (N_S, I_B) exists if and only if given some value of r, γ, k , there exists feasible value of ϕ, ψ and C that make the following four inequalities satisfied simultaneously:

$$\left\{ \begin{array}{l} \frac{1}{2}\phi \geq \frac{1}{2}\phi + \frac{1}{2}\psi - C \quad (56) \\ \frac{1}{2}\phi \geq \frac{1+r}{2}\phi - C \quad (57) \\ \frac{1}{2}\phi \geq \frac{1+r}{2}\phi + \frac{1}{2}\psi - 2(1+k)C \quad (58) \\ \frac{1}{2}\phi - C \geq 0 \quad (59) \end{array} \right.$$

Simplifying the above yields:

$$\left\{ \begin{array}{l} \psi \leq 2C \quad (60) \\ \phi \leq \frac{2C}{r} \quad (61) \\ \psi \leq -r\phi + 4(1+k)C \quad (62) \\ \phi \geq 2C \quad (63) \end{array} \right.$$

To satisfy (60), (61) and (63), it requires:

$$\frac{2}{r}C \geq 2C \Rightarrow r \leq 1 \quad (64)$$

For $k \geq 0$, (62) is non-binding if the equilibrium exists. (62) is the condition by which N_S is a better choice for seller than IO_S , given buyer chooses I_B . If $\psi \leq 2C$ and $k \geq 0$, IO_S is dominated by I_S . So if the payoff of N_S for seller is above that of I_S , then it is also above that of IO_S . That is, if (61) is

satisfied, (62) is satisfied. So given $k \geq 0$ and $r \leq 1$, if and only if ϕ, ψ satisfy

$$\text{Max}\{2C, \frac{C}{r}\} < \phi \leq \frac{2C}{r} \text{ and } C < \psi \leq 2C, (56-59) \text{ can be satisfied.}$$

For $0 > k > -\frac{1}{4}$ and $r \leq \frac{1}{2}$, (62) is binding. Given such k and r , (56-59) can be satisfied if and

$$\text{only if } \phi, \psi \text{ satisfy } \frac{C}{r} < \phi \leq \frac{2C}{r} \text{ and } C < \psi \leq \text{Min}\{2C, -r\phi + 4(1+k)C\}.$$

For $-\frac{1}{4} \geq k > -\frac{1}{2}$ and $r \leq \frac{1}{2}$, (62) is binding. Given such k and r , (56-59) can be satisfied if and

$$\text{only if } \phi, \psi \text{ satisfy } \frac{C}{r} < \phi < \frac{(3+4k)C}{r} \text{ and } C < \psi \leq -r\phi + 4(1+k)C.$$

For $0 > k > -\frac{1}{4}$ and $1 > r > \frac{1}{2}$, (62) is binding. Given such k and r , (56-59) can be satisfied if and

$$\text{only if } \phi, \psi \text{ satisfy } 2C < \phi < \frac{2C}{r} \text{ and } C < \psi \leq \text{Min}\{2C, -r\phi + 4(1+k)C\}.$$

For $-\frac{1}{4} \geq k > -\frac{1}{2}$ and $1 > r > \frac{1}{2}$, (62) is binding. Existence of (N_S, I_B) requires that,

in $\phi - \psi$ space, the ϕ where $\psi = -r\phi + 4(1+k)C$ and $\psi = C$ intersect must be larger than $2C$, which is:

$$\frac{(3+4k)C}{r} > 2C \Rightarrow r < \frac{3}{2} + 2k \quad (65)$$

Given (65), (56-59) can be satisfied if and only if $2C < \phi < \frac{(3+4k)C}{r}$ and

$$C < \psi \leq -r\phi + 4(1+k)C.$$

Q.E.D

Equilibrium (N_S, N_B) can not exist.

Proof: Given buyer chooses N_B , rather than choosing N_S which gives him 0, seller can always ensure a positive payoff by choosing O_S .

Q.E.D